6-1-2010

Greening the Green Revolution: Moving Beyond Chemicals to Sustainable Agricultural Practices

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GREENING THE GREEN REVOLUTION:

Moving beyond chemicals to sustainable agricultural practices

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A Thesis

Presented to

The Joseph Korbel School of International Studies

University of Denver

In Partial Fulfillment

of the Requirements for the Degree

Masters of International Development

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by

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June 2010

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Title: GREENING THE GREEN REVOLUTION
Advisor: Sarah Hamilton
Degree Date: June, 2010

Abstract

Agriculture has dominated the economy of many developing countries for centuries, which has led to development policies that center on agricultural development. An obvious approach to improved production is to decrease agricultural losses in the fields and increase efficiency to markets. This study focuses on the developmental role of pesticides and chemical fertilizers on non-traditional agricultural export farming and the adoption of IPM techniques. With farmers in the Comayagua Valley of Honduras, an Asian vegetable production center for the country, as the study population, the costs and benefits of planting oriental vegetables was examined. Statistical analysis was used to examine factors contributing to a farmer's decision whether or not to adopt integrated pest management techniques. Agricultural practices and economic data were compiled through personal surveys. Farm locations were tagged using a GPS handheld unit for distance modeling. Despite a small study sample some observations were made. Chemical cost accounted for more than 50% of the expected return and correlations were found between land access and the use of fixed traps and barriers. Observations made during this study have indicated areas and directions for future studies.

Acknowledgements

A special thanks to my advisor Dr. Sarah Hamilton, who helped arrange this research opportunity and was a motivating and supportive throughout the research and writing of my thesis. I would also like to thank Dr. Paul Sutton and Dr. Sharolyn Anderson for their help with the GPS data configuration, and Dr. Mauricio Rivera and Roberto Tejada and the staff of the Honduran Agricultural Research Institute headquarters who introduced me to FHIA's work and agriculture and pesticide use in Honduras. A special thanks to the staff at the Comayagua FHIA field station, especially the *ingenieros*, Dario Fernandez and Reinan Maurcía who helped me reach and contact farmers, and the rest of the staff that helped me get oriented in Comayagua, helped with translations and in understanding pesticides in Honduras.

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CHAPTER ONE: INTRODUCTION

Agriculture has dominated the economy of many developing countries for several centuries. More than 70% of the population in poor countries live in rural areas and 97% of this group is involved in agriculture (Brodesser et al. 2006, 3). In light of these statistics several development strategies have centered on agricultural advancement. In the 1960's, international governments and development organizations promoted the green revolution as the process of industrializing agriculture, and the development of export markets (Stonich 1993, 8). In order to increase agricultural production, research institutes developed a variety of technological advances which included breeding high-yield and climatic resilient plant varieties. Other advances included improved agronomy practices, inorganic fertilizers, pesticides and mechanization of certain agricultural processes, for example the development of irrigation systems and the use of tractors for plowing and harvesting (Murray 1994, 3). Although originally the green revolution focused on increasing production of rice and wheat, it has expanded to include other crops important to developing countries, such as sorghum, millet, maize, cassava, and beans, allowing countries like India, China and some Latin American countries to achieve food sustainability and become food exporters (IFPRI 2002, 1).

One of the largest obstacles facing agricultural production is the prevalence of various pests, including a wide range of diseases, weeds, insects, fungi, and animals. Brodesser et al (2006) found that without the use of pesticides farmers would lose nearly

70% of their agricultural production. As it is, farmers lose up to 42% of their produce in the field and another 10% after harvest. The easiest way to increase production is to decrease agricultural losses in the fields and increase efficiency to markets. During the 1940s and 50s, following the development of DDT, the creation of new pesticides climbed and sales jumped from $40 million annually to $260 million (Murray 1994, 13-15). Unfortunately, these chemicals are expensive and frequently have human health and environmental risks associated with them. Despite this, farmers continue to use them. NGO's and other development organizations have been promoting integrated pest management (IPM) and organic markets since the 1980's. However, these strategies require significant understanding of biological and agricultural systems and connections to venues to sell "organic" produce.

This study focuses on the developmental role of pesticides and chemical fertilizers on non-traditional agricultural export farming and the use of IPM techniques. By looking at farmers in the Comayagua Valley of Honduras, the Asian vegetable production center for the country, this study will examine the costs and benefits of planting oriental vegetables. The literature review provides background information on the history and risks of agro-chemicals, a brief overview of the agricultural market and development in Central America, an introduction to non-traditional agricultural exports (NTAEs) and specifically on these three areas in Honduras. The data presented here considers the economics of using chemicals in Asian vegetable production and evaluates some of the decision making factors for using IPM strategies. It is my expectation that economic factors will dominate IPM adoption decisions. For example, chemical costs will drive adoption of less costly practices.

History of Pesticides

The world's population is growing at a rapid rate with increasing rural to urban migration, with the result that two thirds of the population is now living in towns and urban centers. This continues to place an ever increasing demand on agricultural production and distribution systems. In order to increase agricultural production, a variety of technological advances have been implemented which include improved agronomy practices, inorganic fertilizers, pesticides, breeding of highly productive and climatic resilient plant varieties, and the mechanization of certain agricultural processes, for example the development of irrigation systems and the use of tractors for plowing and harvesting (Murray 1994, 3). All these new inputs led to what has been described as the Green Revolution, which uses ideas and practices introduced during the Industrial Revolution for the production of food and fiber (Longo and York 2008, 82). The adoption of Green Revolution technologies and new plant varieties more than doubled cereal production in Asia between 1970 and 1995 (IFPRI 2002, 1). In Central America, these technologies resulted in the cotton boom which lasted for three decades (Murray 1994, 16-17).

Increasing the efficiency of agricultural production implies cutting agricultural losses due to pests as well as increasing production on limited areas of land. There is a decreasing availability of unused land, so maintaining and increasing yields on current, nutrient drained land relies on the use of fertilizers. Currently, fertilizers provide about 43% of the nutrients which crops extract from the soil each year and this percentage is estimated to continue its upward trend in the future. In northern Europe alone fertilizer use has increased from about 45 kg/ha in 1950 to 250 kg/ha in the early 2000's (Fresco 2003).

One of the largest obstacles facing agricultural production is the prevalence of various pests, including a wide range of diseases, weeds, insects, fungi, and animals. The application of chemicals as insect deterrents began in the late 1800's with the use of sulfur and nicotine. In the early 1900's, the United States Department of Agriculture (USDA) started promoting calcium arsenate in the form of a fine dust spread over the crops as an improved form of insect control, especially effective for the boll weevil that plagued the cotton industry. Then in 1939, Paul Müller revolutionized chemical pest control when he discovered the insecticidal properties of a previously developed compound, I,I,I trichloro-2, 2-bis (parachloro-phenyl) ethane, more commonly known as DDT. This discovery completely changed the pesticide industry and was heralded as a miracle pesticide. In 1944, Sints reported in *Popular Science* that, "At last science has found the weapons for total victory on the insect front" (as quoted in Murray 1994, 13). DDT was followed by the discovery and development of twenty-five other chemical compounds which included BHC (benzene hexachloride), chlordane, toxaphene, aldrin, parathion, methyl parathion, and tetraethyl pyrophosphate between 1945 and 1953. During the same decade, pesticide sales jumped from $40 million to $260 million (Murray 1994, 13-15). In recent decades, pesticide consumption has risen at an estimated annual growth rate of 5% per year. In Latin America, pesticides sales increased by 30% in 2003 putting sales at US$ 5.4 billion in 2004 (Brodesser et al. 2006, 1-2).

Pesticides and Health:

Since the discovery of DDT, scientists have been studying pesticides and their effects on humans. Many pesticides are classified as extremely or highly toxic by the World Health Organization (WHO) and are banned or restricted in the United States and Europe as known animal carcinogens, neurotoxins, reproductive toxins, or endocrine disruptors (Wesseling et al. 2005, 699). Most of the original pesticides belonged to the category of organochlorines, which are slightly less acutely toxic than the organophosphates, but more persistent and have been linked to severe health and environmental problems caused by bioaccumulation over time. Organophosphates and carbamates have rapid breakdown rates and therefore are considered to be more environmentally friendly but, due to their mode of action as cholinesterase inhibitors, are more acutely toxic (Wesseling et al. 2005, 698). These compounds, especially the organophosphates, are neurotoxins that can cause sensory and motor impairments that usually develop days or weeks after exposure (Miranda et al. 2002, 19). Other pesticides that are causing an increase in incidents of poisonings include the herbicide paraquat and the fumigant methyl bromide (Thrupp 1995 103-106; Wesseling et al. 2005, 698). Paraquat is a widely used herbicide that can cause severe damage to the lungs, liver and kidneys. Small doses can cause nausea, vomiting, abdominal pains and diarrhea (CDC). Despite WHO's classification of moderately toxic, paraquat has led to thousands of deaths worldwide, due to its availability for suicide in developing countries (Wesselin et al 2005, 698). Methyl bromide is frequently used to fumigate soil, food and non-food commodities for storage and transport. The USA Environmental Protection Agency has categorized it as Category I, acute toxin. Symptoms range from lung congestion and headaches, nausea and visual abnormalities to seizures and death. In the long run, methyl bromide can cause impaired motor coordination, muscle aches, worker fatigue and even increased chance of cancer. It is also a reproductive toxin, affecting hormonal functions and can depress the immune system (Thrupp 1995, 103-104).

In 2000, an agreement between the Central American countries and the Dominican Republic (RESSCAD) identified twelve pesticides most frequently associated with acute poisonings and recommended that these pesticides be banned or restricted in the region. These chemicals, sometimes referred to as the 'dirty dozen' include aldicarb, aluminum phosphide, carbofuran, chlorpyriphos, endosulfan, etoprophos, methamideophos, methomyl, methyl parathion, monocrotophos, paraquat, and terbufos (Murray et al. 2002, 243-246). Of these pesticides, five are listed as Class IA, extremely hazardous, by the WHO and four are classified as Class IB, highly hazardous, and three are classified as Class II, moderately hazardous (WHO 2004). The high toxicity of these compounds has led to a high occurrence of acute pesticide poisonings. WHO estimates that there have been as many as twenty-five million poisonings from pesticides in the developing countries with more than one million cases of severe poisonings per year, and a fatality rate between 0.4 to 1.9% (Rengam 1999, 15; García 2003, 592). In Central America there were 6,934 cases of acute pesticide poisoning in 2000, at a rate of about 20 poisoning per 10,000 people for the region. El Salvador, with 2,349 poisonings, and Nicaragua, with 1,651 poisonings, each represent high risk countries with poisoning rates of over 35 cases per 10,000; 36% of these cases are related to occupational hazards, followed by accidental and intentional poisonings. After adjusting for the population that is involved in agriculture, this figure jumps to 48 agricultural workers per 10,000 in 1999 and 37 in 2000, almost twice the rate as seen in the general population (PAHO 2002, 6-7).

In addition to increased rates of acute poisonings, pesticides have been implicated as a causative agent of human cancer and recent evidence indicates that pesticides may also increase a person's probability of cancer through several non-genotoxic mechanisms. Pesticides have been shown to increase hormone imbalance, cytotoxicity, and several other processes that ultimately lead to compensatory cell division, or cancer. In other words, it seems that in some cases pesticides are "promoters rather than initiators of cancer" (Hodgson and Levi 1996, 97-99). There have been increased incidence and mortality for certain types of cancers, such as soft tissue sarcoma (SRS), malignant lymphomas (specifically Hodgkin's disease), multiple myeloma, leukemia, and cancer of the skin, prostate, testis, lung, and brain (Dich et al 1997, 424). Ongoing research is continuing to show correlations between cancer and pesticides, especially among women, traditionally an understudied portion of the rural workforce. Women face increased risks of ovary and breast cancer and reproductive complications.

Pesticides can affect human reproduction through both direct and indirect paths. Pesticides can directly affect male fertility by reducing sperm count. Indirectly, some pesticides are structurally similar to hormones resulting in a variety of reproductive effects in women, including increased time to menstruation and early menopause, resulting in reduced reproductive years and ability to carry a child to term. Developmental effects occur to the fetus and are usually a direct result of the pesticide exposure of the mother during pregnancy. The embryo is most vulnerable to major birth defects between three weeks and two months. High exposure before the third week most commonly leads to fetal death and high exposure after the second month can lead to growth retardation and functional deficits (Hodgson and Levi 1996, 97-99).

Mounting evidence suggests that there are significant differences in gender-based health risks associated with pesticide exposure. With the identification of gender-specific metabolizing processes for pesticides, and the differences in where the body accumulates pesticides, further research is required to determine the risks associate with gender-related exposures. While there is enough surveillance data to identify common health issues that affect men and women in agriculture, such as increase risk of certain types of cancers, men and women face obviously different risks for sex-related cancers. The effects of pesticides on reproduction have greater risks for the woman and the fetus, and these risks, such as infertility or the inability to carry a child to term, can jeopardize a woman's social status (London et al. 2002, 54).

Pesticides and the Environment:

As the global population and agricultural demands grow, many country's have become caught up in the "pesticide treadmill" where insects and microbial pathogens that cause diseases develop resistance to pesticides, forcing scientist to continue to develop new and more potent chemicals in order to maintain production efficiency (Atreya 2007, 305). Increasing agricultural production puts more strain on the environment and natural resources, resulting in erosion, salinization of soils, water depletion, pollution of land, air and water, habitat and biodiversity loss and ecosystem disruption. Pollution stems from intensive use of pesticides, inorganic fertilizers and fossil fuels, which are needed for the production of chemicals as well as to run the equipment necessary for large scale crop production, as well as for the production of pesticides and fertilizers. Some scientists argue that the Green Revolution and trade liberalization are the cause of environmental degradation and the increasing economic rift between the rich and poor. Critics state that liberalization increases demands on the environment through high output production that is typically "resource intensive and waste extensive," which was made possible by the Green Revolution (Longo and York 2008, 86). The booms of export agriculture have caused extensive deforestation and land erosion in Central America. Between the years of 1950 and 1963, more than 153,000 ha of forest were cleared in only eight municipalities of Guatemala. Deforestation cleared land for mono-crop production systems that used heavy machinery and intensive irrigation and pesticide application systems. Rain and wind erosion annually accounted for an estimated sixteen to twenty tons of top soil relocation in Central America, making the region the world leader in soil degradation percentages. In 1992, the world average for soil degradation was 10.5% and in Central America it was 24.1% (Murray 1994, 41-42).

Pesticide contamination in areas of intense agriculture resulted in high toxic levels in the soil as well as in local water sources. In Nicaragua, contamination of rivers has resulted in massive fish kills throughout the length of river systems, affecting fish and human populations downriver that were not necessarily connected to agriculture and pesticide use (Hruska and Corriols 2002, 192). Indigenous groups saw a decline in shellfish, crayfish and other river and estuary life, causing a decrease in their food security. Also, farmers and fishermen on the coast of El Salvador experienced a threat to their livelihoods as the shrimp population off the coast dwindled (Murray 1994, 42). The mangrove forests that support the Honduran shrimp industry have been negatively affected by inland pesticide use. In 1993, water tests in the Gulf of Fonseca revealed high levels of Heptachlor, Aldrin, Lindane, Endosulfan or Malathion. Endosulfin and Aldrin were also detected in tissue samples of clams (DeWalt et al 1996, 1201).

The breakdown of these chemicals in the environment and the full implication of their presence are not fully understood. Organochlorines are known to be slow decomposers and to persist in the environment in their toxic form, having negative implications for long term environmental conservation and health. The effects of organophosphates in the environment are less understood. They have much faster breakdown rates than ogranochlorines in the presence of sunlight and microbes. However, in groundwater or even in houses or storage rooms where sunlight is absent they have higher persistence. In addition, some of the other newer pesticides found on the RESSCAD list, like aluminum phosphide, produce a poisonous gas almost instantly upon contact with water creating new hazards for the worker (NPIC and EXTOXNET).

Neo-liberalism in Latin America:

Latin America was one of the last areas to feel the effects of globalization and the neo-liberal movement. As with many countries that have a history of colonialism based on the export of raw materials, Latin American countries did not develop strong institutions, laws or enforcement policies (Tabellini 2005, 285). After the Great Depression and WWII, Latin American countries began import-substituting industrialization, which protects the local manufacturing sector by saving the home market for domestic products (Mahon 2003, 58). The idea was that by imposing high tariffs on imports, governments could protect the country's infant industries and that would in turn employ local labor and allow the production of goods that could be sold domestically at cheaper prices than international products. However, import-substitution can be a difficult strategy to implement for several reasons: it takes time to successfully start industries in poor countries, there is often very little money for upfront investments in start-up companies, and the wealthy of a country are not willing to wait for local goods to be available and so undermine domestic industrialization by purchasing imports (Kerbo 2006, 250-251). After experimenting unsuccessfully with import-substitution industrialization, most Latin American countries were unable to pull themselves out of debt because local industries could not develop fast enough to cover the start-up costs or operate efficiently enough to compete in the international market (Mahon 2003, 59).

In the 1960's, neo-liberalism became a popular developmental theory and one of the central tenets of the neo-liberal theory is trade liberalization, which is the process of reducing barriers to trade thereby opening markets in all countries to vendors and consumers from all other countries. In order to accomplish this, governments implement a series of market friendly policies, reduce taxes and tariffs, open their borders to foreign direct investment, and decrease regulations on trade and local corporations (Longo and York 2008, 87-92). The Washington Consensus, developed in 1989 by John Williamson, is a package of ten policy recommendations for the liberalization of a county's economy and politics. The central tenets of the Washington Consensus are fiscal discipline, reorientation of public expenditures, tax reform, financial liberalization, openness to foreign direct investment, privatization, deregulation, and secure property rights. This package was adopted by the Bretton Woods Institutions, most notably the World Bank and the International Monetary Fund (IMF) and assumed to be the key to getting poor countries out of debt and rejuvenating their economies (Hobden 2008, 57-59).

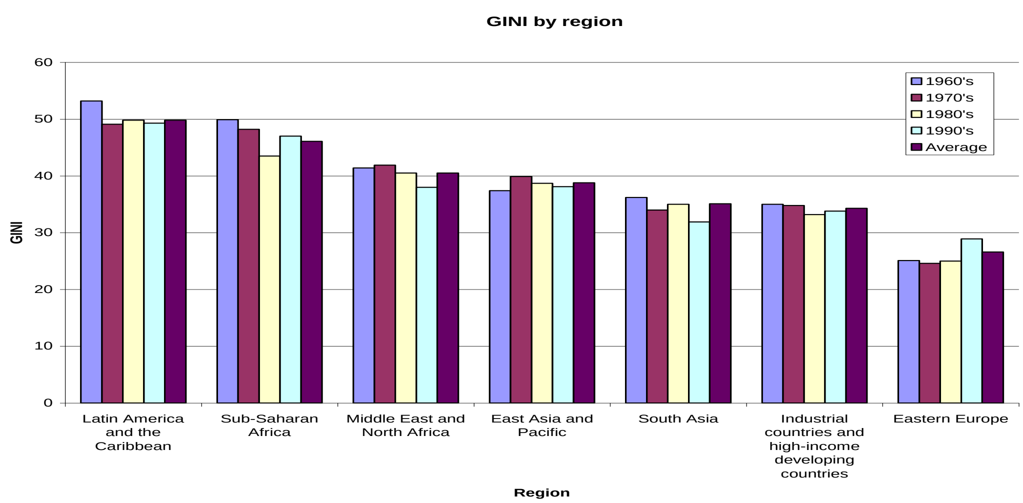
The theoretical framework of neo-liberalism as a development tool is that poor countries will be able to capitalize on the resources that they have, like raw materials, cheap labor, and agricultural land. If these resources can be sold on the global stage at fair market prices, this then will stimulate economic growth. With trade liberalization, international corporations can enter and help countries develop a variety of economic sectors such as agriculture and manufacturing industries, to the benefit of the country (Watson and Achinelli 2008, 225). This will lead to a modernized economy, increased employment and a trained local workforce, all of which will create jobs and stimulate economic growth. As the economy expands, money will be available for research and further industrial expansion, which will continue to increase production efficiency, local workers will continue to receive training and education and so lead to improved employment levels of local people (Longo and York 2008, 91-92).

However, few countries have actually been able to capitalize on their labor resources and the globalization of natural resources has resulted in the transfer of raw materials and natural resources to developed nations where the raw materials are converted into a final product and then sold back to the original country at much higher prices. Agriculture provides an exception to this cycle, as it is the sole industry in which the raw material is, in many cases, also the final product. However, while the green revolution of the agriculture sector has provided new technology that expands and increases crop production, these innovations are usually only accessible to large landowners and international corporations. The rise of corporate farms and ranches, as well as the increased efficiency offered by the technologies of the green revolution, allows crops to be sold at reduced prices, which makes it very difficult for a small farmer to sell his produce at a price to cover his costs and feed his family (Kerbo 2006, 242).

As a result of pressure from international donors, Latin American governments began adopting the Washington Consensus. One of the principle ideas behind the Washington Consensus is the reduction of the role of the state. The new democracies set up in the late 1970's and early 1980's were now trying to reduce their role while maintaining their power and influence and opening their borders to foreign investors and the global market. This was accomplished through the privatization of the state-run institutions that were set up under the import-substituting model to provide goods and services to the population. However, while several Latin American countries have had some success reducing the role of the state, it is interesting to note that Latin American governments are smaller than governments in Europe or even the United States. In 1992, current central government receipts made up 46% of the GDP in France, 45% in Germany, 38% in the U.S.A. while in 1990 the government receipts made up 20% of the GDP in Argentina, 24% in Brazil, 30% in Mexico and only 10% in Uruguay (Welsch and Carrasquero 2000, 33-34). So, there was very little government left in Latin America to "trim down" and governments are left with very little power to enforce any policy or regulation, whether it is on the market or a criminal act.

History has shown that most governmental adjustment or restructuring programs come at a high price for the local people (Welsch and Carrasqero 2000, 31) and, while there have been some positive outcomes from such programs, the overall trends have been negative. Economic growth in Latin America improved in the early 1990's and then dropped in 1995 and 1998 and has been decelerating steadily since 1999. But the most disturbing trend has been the increasing gap in income distribution and the increasing unemployment rates, especially in the urban sectors (Mahon 2003, 58-59). The democratization and the restructuring of the economic policies did not improve the condition of the lowest ten percent of the population. The slight GDP increases that were seen in the early 1990's was overshadowed by the untamed inflation rates while real salaries never recovered from the economic crash in the 1980's. At the same time, the top ten percent of the population increased its share of the income by four percentage points in Argentina, three points in Brazil and Chile, and an astonishing eight percentage points in Mexico (Welsch and Carrasquero 2000, 32). This trend is evident in the GINI Indices for Latin American countries which indicate that not only does Latin America have the highest inequality in the world but that it has maintained high inequality since the 1960's, as shown in Figure 1. The GINI Index is a scale from 0 to 1 where 0 represents perfect equality and 1 represents perfect inequality (Law and Democracy in Latin America 2005).

Figure 1: GINI by region as percents, Source: Law and Democracy in Latin America 2005



Agriculture in Central America

A chain of volcanic activity extends along the Pacific coast of the Central American isthmus and provides the region with a high level of soil fertility, which when combined with the tropical climate, seasonal rains and long growing seasons, makes the region a perfect place for farming, especially for cotton production (Williams 1986, 13). Through the 1950's, '60's and '70's, development focused on agriculture, with the idea that agriculture would provide food security and quick capital that would stimulate the development of Third World countries (Murray 1994, 2). This system of development is dependent on international demand, and as a result has seen many booms and busts. Initially, agricultural development focused on cocoa, indigo and coffee, which were rich in abundance and easily grown. However, when decreasing indigenous labor forces couldn't maintain production, these economies fell into crisis (Brockett 1998, 1-19). The agricultural exports that have been grown in the region since the early nineteenth century are frequently called "traditional agricultural exports" and include coffee, bananas, sugarcane, and cocoa. Shortly after the coffee bust in the 1940's, these plantations expanded their export portfolio to include cotton and beef (Thrupp 1995, 14). Cotton is native to Central America and was grown prior to the colonization; however, it persisted in low land areas that were prone to diseases, especially malaria. It wasn't until the development of DDT and the control of malaria transmitting mosquitoes in the 1940's that cotton production expanded and became an export commodity (Murray 1994, 11-15).

The cotton and cattle boom and the industrialization processes of the green revolution increased the already unequal land ownership system in Central America. Large landowners wanting to capitalize on cotton or beef needed more land, and used a variety of tactics to accomplish this goal, such as: increasing rent of land, demanding upfront cash payments for rented land, and in some cases simply and sometimes violently expelling peasants from the land (Brockett 1998, 43-48). The cotton boom caused production to jump from 73,000 ha of cotton in 1951 to 135,000 ha of cotton in 1954 and continue to climb into the late 1970s, peaking once in the mid-1960s and again in the late 1970s (Murray 1994, 18-19). Cattle production followed a similar trend, jumping from 4.7 million head of cattle on 8.5 million acres before the boom to 10 million head on 20 million hectares, more than was used for all other agriculture combined (Williams 1986, 113).

This jump in export agriculture allowed economic development throughout the region, but also led to severe land ownership and access inequalities. Families with less than 10 ha represented 86.7% of landowners in El Salvador, 83.9% in Guatemala, 72.6% in Costa Rica, 65.8% in Honduras and 59.9% in Nicaragua (Brockett 1998, 75). Development efforts, credit programs and the seemingly infinite ability of the world market to absorb cotton and cattle encouraged local entrepreneurs to invest and expand production. One of the ways landowners expanded was to demand up-front money for rents, which the tenants couldn't afford and so were forced to leave the land (Kay 2001, 744). Sieder reported that in Honduras "by 1965 an estimated 63,120 rural families – 26% of the population – were landless" (1995, 108) and by 1974 the population of landless peasants had increased to 103,621, or 36% of the population (Ruhl 1984, 47). Plantations continued to evict peasants and illegally close off national and communal lands so that by 1972 59% of all the agricultural land was producing for export (Brockett 1998, 52). The rapid expansion of export agriculture caused a decrease in the amount of land used for food crops and resulted in per capita decrease in food production by 19% (Brockett 1987, 76). This not only created a suddenly landless and malnourished peasant population, but also eroded the social system of patronage that had existed since the Spanish colonization (Kay 2001, 744).

Increasing input costs, sinking international commodity prices, deteriorating regional markets and growing debt burden sent the Central American region into economic crisis in the 1970’s (Stonich 1993, 9). The crisis struck hardest in Guatemala, El Salvador and Nicaragua, since they had a higher dependence on cotton, which is naturally input intensive. Producers reduced the amount of cotton they grew and relied more on technological inputs, such as tractors, to reduce labor costs. However, they did not return unused lands to peasant renters. So, not only were peasants denied access to land ownership or renting, but they also no longer had seasonal work on the plantations (Williams 1986, 162-164). In the 1970’s, two world-price crashes triggered peasants’ movements that swept through Latin America. The first round of uprisings took place in 1973-1975 and the second began in the late 1970’s. Both were followed by escalating violent revolutions, which in some cases ended with civil war. These peasant movements were frequently associated with land seizures, peasant strikes, displacement of large populations and violent military repression (Madrazo 1988, 94-95).

By the 1980’s, most Central American governments had instituted Land Reform Laws and peasant and military activity was coming to an end (Brockett 1998, 222). During this time of civil strife and land reform, these countries incurred substantial debt. In order to reduce these debts and stimulate economic growth, international donor organizations and governments encouraged Latin American countries to cut back on government spending and to implement neo-liberal policies that relied on the market to increase efficiency and equality in agriculture. “Market-friendly” agrarian reforms are based on three claims: that small farmers have a competitive edge over large farmers because they don’t have large labor costs; that this competitiveness will be activated by granting small farmers full property rights; and that the market can weaken the current ownership structure and inequalities, thereby increasing efficiency and agricultural growth (Boucher et al. 2005, 108).

Non-Traditional Agricultural Exports

Two tactics are typically proposed to achieve agricultural efficiency. One way to increase output while maintaining or decreasing input is by practicing extensive agricultural production using green revolution technologies. This usually requires large amounts of land in production under a monoculture system and can be applied to either staple foods, like rice or wheat, or non-staple crops, such as cotton. Another way to intensify agricultural production is through diversifying and intercropping to maximize the output of limited land (Krznaric 2006, 112). Most small farmers do not have the resources needed to profit from extensive agriculture, so they diversify their production to include a variety of “non-traditional agricultural exports” (NTAEs). NTAEs are crops that 1) are not typically grown in a particular country, 2) were produced for domestic markets and are now being exported, or 3) are “traditional” crops, but are now being sold to a new market, i.e. “Fair Trade” (Thrupp 1995, 2). These crops, which include snow peas, broccoli, miniature and oriental vegetables, and ornamentals among others, are perceived as an agricultural development strategy that will not only help national economic growth, but also serve as a strategy for the reduction of poverty. These crops tend to be labor intensive, and therefore will improve the area's unemployment rates, and because of their high market value they can be grown on small plots of land achieving higher land use percentages and greater cash flow into the region (Hamilton and Fischer 2003, 83-84).

During the late 1980's this sector grew at an average annual rate of 17.2% in Central America with Costa Rica and Guatemala achieving 348% and 78% growth, respectively. Despite rapid growth, NTAEs represent a small but relatively stable fraction of total land use and export value, accounting for only 22% of all export value in Guatemala in the mid-1990s (Thrupp 1995, 3-19; Brockett 1998, 56-57). However, NTAEs face a number of challenges. For example, many of the NTEA producers are small farmers with less than a hectare of land; in some places in Guatemala farmers have less than 0.5 hectares. These farms tend to be located in remote areas far from distribution centers. Groups of farmers will form cooperatives and will sell their produce as a collective to agro-exporters if they can get their produce to market, but if they can't they will sell to intermediaries that travel the country looking for produce. Unfortunately, these intermediaries pay lower prices than agro-exporters. However, selling at a low price is better than not selling at all and up to three-fourths of the snow pea production in Guatemala is sold to intermediaries (Hamilton and Fischer 2003, 87).

Pesticides in Central America

Pesticides in Central America are typically associated with traditional exports such as bananas, cotton, and coffee. From 1974 to 1975, cotton farmers used 16,072 metric tons of organochlorines and 7,896.9 metric tons of organophosphates (Murray 1994, 16-17). However, the intense use of pesticides has caused resistance to build up in the pest populations, reducing the effectiveness of pesticides. Farmers are then stuck on a "pesticide treadmill", increasing the frequency and toxicity of pesticide applications in an attempt to control growing resistant pest populations (Hruska 2002, 192; Murray 1994, 35-37). Another side effect of the pesticide treadmill is the decrease in predator populations, which don't build up a resistance to toxins as quickly, since they don't feed directly on the plants. The depopulation of predators allows the growth of secondary pests, insect pests whose population was kept at levels so as not to be considered pests. Initially pesticides were created and applied to cotton in order to control the boll weevil; however, this allowed leafworms, cotton aphids and the whitefly populations to expand and cause considerable crop damage. By the end of the 1970's cotton farmers were applying pesticides as many as fifty-six times per season! (Murray 1994, 37-38).

Among NTAEs, pesticide use isn't much better. The conflicting interests of high standards on crop health and appearance coupled with maximum pesticide residue standards of international markets, has caused confusion among small Central American farmers. One of the primary differences between traditional agriculture and non-traditional agriculture is the farmers. The increased push for NTAEs has caused many small farmers to enter the market and add NTAE to their fields alongside their subsistence crops (Murray 1994, 64). Pesticides account for 30-35% of the annual input cost for snow pea and melon production in Guatemala, exceeding $735 per hectare for melons and $2,206 per hectare for snow peas. A survey of 114 snow pea farmers in Guatemala revealed that in 51 cases farmers used unregistered pesticides and in 20 cases farmers used inappropriate pesticides. The use of unregistered pesticides is accredited to the higher prices of registered chemicals and the inappropriate use of these chemicals reveals the farmers' lack of knowledge of plant diseases and the pesticides. When asked why they used pesticides, farmers most often stated that they feared their products would be turned away from international markets for "low aesthetic quality". This is not unfounded, since in 1993 about 16% of Guatemalan snow peas were rejected because of blemishes (Thrupp 1995, 53-54).

The need for farmers to produce healthy crops that are aesthetically pleasing and can survive a long transportation process has led to increase use of pesticides during the growing season and after harvest. However, the international markets also have maximum residue levels that are permitted on certain foods. These standards address both the type of pesticide permitted on a crop and the amount (Thrupp 1995, 6). Table 1 shows the amount of agricultural imports into the US from the top fifteen producer countries and the percent that was tested to have above the maximum residue levels (Galt 2009, 469). Between 1984 and 1994, the U.S Food and Drug Administration (FDA) detained 14,000 shipments from the Latin American and Caribbean countries resulting in a loss of over $95 million to producer countries. During this time, the U.S. FDA detained 3,168 shipments from Guatemala, resulting in slightly less than $18 million in losses (Thrupp 1995, 6). In response to increase pesticide regulations on imports, farmers have started using more organophosphates and carbamates, since these pesticides have rapid breakdown rates and therefore won't be detected by international customs. Eight of RESSCAD's "dirty dozen" are organophosphates or carbamates (NPIC and EXTOXNET).

Table 1: Vegetable imports and percent shipments with adverse residual levels

Country	MT* (1996-2006)	% Adverse residues (1996-2006)
All importing countries	36,221,444	5.2
Mexico	23,574,040	4.6
Canada	8,311,604	1.9
Costa Rica	953,932	4.4
Peru	800,239	1.9
Netherlands	499,701	1.1
Dominican Republic	296,931	7.8
China	277,847	13.2
Honduras	264,148	7.5
Guatemala	207,699	18.3
Chile	151,054	1.9
Panama	100,519	5.7
Israel	92,751	2.2
Argentina	91,165	2.8
Spain	90,443	17.5
Jamaica	83,069	13.6

Source: Galt 2009, 469
*MT – metric tons

Credit and Agro-exporters

The idea behind the property rights tenet of the neoliberal movement in Latin America was that by handing farmers the title of their land, they could now offer it up as collateral in order to obtain credit to improve their production and become active participants in the market and in their own development. However, this movement, which placed the responsibility for development on the free market, also reduced the amount of government subsidies. The government essentially stopped all agricultural subsidies as a result of government reduction and the switch to market-led development, which had a negative impact on local small scale grain production and small farmers' income and food security (Hetch et al 2006, 318).

One requirement banks and agro-exporters impose on farmers is the use of pesticides. Pesticides are viewed as a risk reducing strategy, since they are proven to reduce the occurrence of pest infestations and subsequent crop losses. In the 1990s, banks required farmers to provide written documentation of proof that they have a history of using pesticides on their farms and then, once the credit has been granted, the farmers had to agree to continue to use pesticides. In Costa Rica, in the late 1980's to early 1990's, banks had an intensive prophylactic pesticide regiment that included a recipe of pesticides (types and amounts) and a calendar for pesticide application. In order to establish this regimen, banks contact technical experts from the pesticide companies and from the Ministry of Agriculture, who rarely deviate from the pesticide companies recommendations. Since pesticide companies sell products in different countries with different geographical and climatic variables, companies typically prescribe recommendations to reduce risks over a broad base of scenarios and "worst case" situations. This regimen did not take into consideration local variations that may make the pesticide ineffective (like heavy rainfall that washes the pesticide away from the field and into water sources) or inappropriate (like spraying for a pest that may not yet be a problem, thus killing its predators). After a farmer has proven that he uses chemical inputs, usually by providing receipts, banks had a team of technical personnel who monitored the banks agricultural investments by policing the farms and farmers to make sure they are following the chemical regimen. This process not only gets farmers stuck on the pesticide treadmill, but also requires that they take out larger loans as up to 48% of the loan goes towards agro-chemicals, and most of this is on pesticides. Both of these components insure that not only will the farmer's crop not crash, but that the farmer will continue having to take out loans every season (Thrupp 1990, 64-66).

Management Techniques

A variety of different tactics ranging from government regulation of toxic chemicals to NGO and government sponsored training programs and buyer driven market movements have been proposed and tried over time. A major step in restricting international pesticide trade came in 1995 when the UN Environment Programme identified twelve persistent organic pollutants (POPs) for a global phase out. Then in 2004, Prior Informed Consent (PIC) became a legally binding treaty which stated that countries should share data concerning dangerous pesticides. Currently there are twenty-four pesticides on the PIC list. Basically countries must notify each other of the health and environmental data of the pesticides on this list and the data are put into a decision guidance document that is then circulated among the signatories (Smith 2001, 266; Galt 2008, 788-789).

At a more regional level, in 2000, the Ministries of Health for all Central American countries and the Dominican Republic identified the 12 most problematic pesticides in the region and signed a recommendation (RESSCAD) for their regulation within the region. For some of the pesticides, the ministers recommended their complete ban from the area and for others they recommended stricter controls of import and use (Murray 2002, 243-244; Rosenthal 2005, 438). However, in 2004, the Central American-Dominican Republic Free Trade Agreement (CAFTA-DR) was signed to "eliminate tariffs and trade barriers and expand regional opportunities for the workers, manufacturers, consumers, farmers, ranchers and service providers of all the countries." (CAFTA-DR 2004). One of the proposed accords put forward by this agreement was the Central American Customs Agreement, which would encourage and facilitate trade within the region by reducing tariffs and regulation. One of the unresolved problems of this agreement is the regulation of products coming into the region, pesticides being a primary concern as the countries currently have different pesticide regulation laws. In response to the Food and Agriculture Organization (FAO's) of the United Nations Code of Conduct on the Distribution and Use of Pesticides and the RESSCAD resolution, countries like Honduras and Nicaragua have attempted to control toxic pesticides within their borders. However, this is proving difficult. In Nicaragua, the Pesticide and Toxic Substances Law of 1998 gave the Ministry of Health the authority to require toxicological evaluations for chemicals seeking registration. This also gives public agencies and civil society organizations (CSOs) the right to demand that the Ministry of Agriculture perform these evaluations for currently registered chemicals for which new data on their adverse effects is available. In 2001, under Law 274, the Ministry of Health along with some CSOs passed a report to the Ministry of Agriculture requesting a reevaluation of the twelve pesticides identified by RESSCAD resolution. The report called for banning of three of the pesticides and the restricted use of the other nine. However, as of 2004 the Central American countries were still in the process of drafting a Unified Registry for pesticides trade within the region. The document would remove regulation from the national level to the supranational level, effectively removing a governments control over pesticide distribution within the country's borders, since pesticide companies could register their product in countries with lower standards, like Guatemala, and then transport the product throughout the area under the CAFTA-DR (Rosenthal 2005, 437-439). Honduras adopted the FAO's Code of Conduct for Pesticides in 1985 and in 1991 banned fourteen Class1 pesticides. However, most of these chemicals are still widely used in Honduras today. CAFTA-DR is only one reason why these chemicals are still prevalent in Honduras; another is the weak central government that has difficulty enforcing import laws and regulations in the face of powerful and wealthy pesticide companies (Jansen 2008, 576-577).

Some, including pesticide companies and some government officials, attribute the pesticide problem to lack of education and training. Industry representatives point to the increased yields without increased health problems in some areas that are permitted by the use of their chemicals and claim that they cannot be held responsible for ignorant farmers that choose not to wear protective clothing or continue to stir pesticides with their hands (Jansen 2008, 581). In response to this view, government extension services and NGO's have offered technical training in pesticide management and application processes. However, several interviews with local farmers have revealed that the misuse of pesticides is not necessarily linked to lack of education or training, but perhaps a lack of understanding on the companies' part. In many developing countries poverty, poor enforcement of government regulations, inappropriateness of protective clothing and cultural attitudes combine to make "safe-use" models for pesticide management ineffective. Many of these farmers live in tropical areas where the heat makes the use of protective gear uncomfortable and puts farmers at risk for heat stroke. The high humidity of these areas results in saturation of sweat and pesticides through clothing, such as thick shirts especially when using a backpack style pesticide sprayer. Studies have also found that gloves are almost always contaminated on the inside especially when reused over a long time frame; sweat can mix with pesticide fumes and run down the arm, or simply from handling pesticides and then inserting the hand into the glove. In addition to the inappropriateness of protective gear in tropical climates, poor farmers cannot afford most of the recommended gear, or timely replacements, as in the case of gloves. The farmer's need to feed his family overrides his knowledge of pesticides hazards and his economic inability to protect himself (Hruska and Corriols 2002, 191-199; Aragón et al, 2001, 298-300).

Researchers argue that safety-training is not sufficient to reduce health and environmental hazard caused by pesticides. Instead, as Hruska and Corriols (2002) observed, "farmers should be better managers of their crops, to achieve both their goals and those of their family, as well as the goals of society" (192). In order to achieve this goal, many NGO's have promoted pesticide reducing strategies, such as integrated pest management (IPM), since the 1970's (Aragón et al 2001, 297). IPM has several definitions, but is generally understood as a flexible and holistic approach to crop management which uses a variety of biological, cultural, genetic, physical, and chemical techniques to maintain overall system health while reducing environmental disruptions (NRI 1994; Mey 1999, 40). In order for this system to be successful, NGO's seek to educate farmers in basic biology and ecology of agro-ecosystems and how to think critically in order to manipulate the system in order to reduce pests and maintain plant health. It is also important that farmers understand how to problem solve and discover creative solutions to existing pest problems and then to experiment. When participatory training is successful, farmers decrease their use of pesticides and maintain crop yields. In a field study in Nicaragua, Hruska et al (2002) found that while there was no increase in crop yield under IPM, there was no decrease either and the reduced input cost allowed farmers to increase their returns.

As stated above, an important component of this system is cultural. NGO’s and IPM trainers must be aware of local cultural traditions and build on these ideas to establish a management system that is both effective and sustainable. Many indigenous societies possess traditional agricultural knowledge and practices that do not rely on heavy pesticide use. These farmers inherit knowledge from their fathers and continuously build upon it from their own experiences and as a result have as good an understanding, and perhaps a more intimate knowledge, of the local ecology and pests as the outside “experts”. A study of a Mayan group in the Guatemala highlands revealed that they already practiced twenty-six preventative techniques to reduce insect damage in the fields and in storage, especially on their food crops. They have a different attitude towards non-traditional crops that are grown for market. These crops are foreign to their traditional knowledge and so farmers adhere to outside advice for management of these crops (Morales and Perfecto 2000, 50-55). However, agriculture is a risky business and some farmers prefer to reduce their risks as much as possible and without complete, comprehensive understanding of IPM, farmers will adopt IPM strategies without reducing their pesticide use. By employing both techniques they believe they will get the best of both worlds and further reduce the risk of crop loss to pests. For IPM to be an effective pesticide reduction strategy, comprehensive training and education programs must be available (Aragón et al 2001, 300).

The use of IPM strategies has been increasing in recent decades with the increasing popularity in organic and fair trade markets. Buyer-driven, certified markets have potential as a tool for both poverty reduction and environmental conservation. Their power is derived from their “ability to garner producer support via the promise of consumer loyalty, market shares, and often price premiums" (Reynolds 2007, 148). While fair trade focuses on the social aspect of trade and the market, organic focuses on environmental aspects of production. The original organic movement was intended to encourage organic or traditional production, as well as decreased chemical inputs. Traditional production methods are low tech and promote soil conservation and increased diversity. However, large farmers are increasingly entering this market. Organic certification of large producers has limited environmental influence, since large producers typically continue to use technologically intensive methods of production that advance soil degradation and only use a portion of their land for the organic market, saving the rest of their land for regular markets that are input intensive. Another constraint in organic production is the small size of the current market, only 15% of all organic produce is sold internationally and only 5% is sold as 'organic'. However, the overall effectiveness of these markets as a tool for environmental conservation depends a lot on the criteria and regulation of the certification process (Tovar et al 2005, 463-656).

Honduras

Honduras is the second largest Central American country with an area of 43,277mi^2, slightly larger than the state of Kentucky (DeWalt, et al. 1993, 106). However, much of the land is mountainous with some 60.8% of the total surface area on slopes of more than 40% inclination and 80% with a slope of more than 12% (Jansen et al. 2005, 1 and Durham 1979, 107). Furthermore, the volcanic axis that runs down the Pacific coast of Central America increasing soil fertility in the region passes through the Gulf of Fonseca, bypassing Honduras and depositing most of the fertilizing volcanic ash off the coast, further reducing the country's arable land. Durham calculated the average production differential of maize production between Honduras and El Salvador for 1950-1952 and found that yield in Honduras was only 65.9% that of El Salvador (Durham 1979, 107-108). Despite low percentage of arable land and low soil fertility, 60% of the population lives in rural areas. Honduras is one of the poorest countries in Latin America with 59% of the population below the poverty line in 2004. The total population is 7.8 million with an annual growth rate of 2% and a 36% rate of un- or under employed. The per capita income for 2002 was US$ 920 and in 2009 the national GDP was US$ 33.14 billion (CIA, 2010; Jansen et al. 2005, 3). Tables 2 and 3 show the overall structure of the Honduran economy in terms of GDP and national trade of the major commodities.

Table 2: Structure of the Economy

(% of GDP)	1988	1998	2007	2008
Agriculture	21.2	19.1	12.9	13.6
Industry	24	30.7	30.1	31
Manufacturing	15.1	18.6	21.3	21.7
Services	54.8	50.2	57.1	81.6
Household final consumption expenditure	67.5	66.6	78.9	83.5
General gov't final consumption expenditure	14.1	10.1	16.7	16
Imports of goods and services	28.9	54.1	80.7	81.6
(average annual growth)	1988-98	1998-08	2007	2008
Agriculture	3.3	3.7	5.7	3.4
Industry	3.5	4.3	5.2	4.4
Manufacturing	3.6	5.3	4.3	3.8
Services	3.4	5.8	7.5	5.7
Household final consumption expenditure	3	5.6	8.1	7.1
General gov't final consumption expenditure	-1.9	6.8	18	-0.5
Gross capital formation	8.6	5.2	18.8	13.6
Imports of goods and services	3.5	7.1	11.9	8.8

Source: World Bank 2009; http://devdata.worldbank.org/AAG/hnd_aag.pdf

Table 3: Trade

(US$ millions)	1988	1998	2007	2008
Total exports (fob)	881	1,613	2,281	6,100
Bananas	356	220	289	NA
Coffee	192	430	516	NA
Manufactures	NA	NA	379	2,377
Total imports (cif)	1,010	2,535	6,983	9,742
Food	190	288	1,142	NA
Fuel and energy	117	214	1,305	NA
Capital goods	215	887	1,749	7,780

Source: World Bank 2009; http://devdata.worldbank.org/AAG/hnd_aag.pdf

Due to its lack of abundant fertile soils, the cotton boom in Honduras was fairly modest compared to that which occurred in the cotton industry of other Central American countries. Despite this, land under cotton production went from 16,245 acres in the 1950's to 35,445 acres in the mid-1960's (Williams 1986, 197-200). Cattle production expanded much more rapidly. In the department of Choluteca, pasture expanded from 47% of the land area in the 1960's to 64% by 1974 (Williams 1986, 113). The economic crisis of the cotton crash hit Honduras in 1973. Due to lessons learned through organizing against the banana enclave and the mining industry in the 1930's, the Honduran peasants formed organizations such as Federación Nacional de Campesinos de Honduras (FENACH) and Organización Regional Interamericana de Trabajadores (ORIT) and began working for land reform in the early 1960's. ORIT was sponsored by the regime of Villeda Morales, a moderately reformist president (1957-1963) who established the National Agrarian Institute (INA) in 1961 and in 1962 passed the first agrarian reform law (Brockett 1987, 77; Williams 1986, 166-179). However, Villeda was overthrown in 1963 by the Nacional Party (PN), which was closely aligned with the interest of the elites and the banana companies. The regime under López Arellano dissolved the FENACH and initially repressed the peasant organizations. However, despite his initial conservative actions, López slowly became a reformist leader like his predecessor. In the early 1960's, López Arellano declared that the military could not remove peasants from land without the permission of the INA. This ruling effectively gave peasants access to land, since landowners could no longer use their traditional means of evicting them (Sieder 1995, 109-112). However, by the 1971 presidential elections, the PN was able to garner most of the votes and again elect a conservative president. As a result, conflicts over land intensified and erupted in the killing of Unión Nacional de Campesinos (UNC) members. UNC was a peasant organization that was formed after the disintegration of FENACH. The hunger strike that followed was partly responsible for the coup that put López Arellano back in office in 1973 (Brockett 1987, 79). This time he held more populist views and pushed an emergency land reform measure, Decree Law 8, which allowed peasants to temporarily occupy national and communal land. This was followed by Decree Law 170, which placed caps on the size of landholding. Landholdings in excess of the cap would be subject to expropriation and redistribution to the landless (Sieder 1995, 114 -115). Lopéz Arellano promised to redistribute 600,000 hectares of national and expropriated land to 120,000 landless families (Brockett 1987, 79-81).

These laws were very unpopular with the elites. In 1975, before DL 170 could be implemented, they staged a coup and replaced Lopéz with Juan Melgar Castro. Melgar Castro allowed the law to be published two weeks prior to the date it was to become active and then waited six months before enforcing the expropriation of 'unused' land. He also slowly and systematically undercut the power of the INA by removing key people and taking away their power. The organizations of the elites solidified their power within the military and by January of 1977 they had begun to purge the military of reform sympathizers and by February had begun purging peasant cooperatives. By 1978, land reform in Honduras was effectively dead (Sieder 1995, 114-120) until the 1990's when Honduras began implementing economic reforms for structural adjustment and trade liberalization. In 1992, Honduras passed the Law for Modernization and Development of the Agriculture Sector (LMDSA) which replaced the 1975 Agrarian Reform Law. The LMDSA repealed several of the statues of the previous reform law, including the elimination of *minifundios* (five hectares or less), the prohibition of the sale of group owned land by individuals in the cooperative, and the ban on renting land by land reform beneficiaries. In addition, LMDSA

> promoted the titling of land to individuals or couples holding 'illegally occupied national lands' prior to 1989. It also strengthened women's formal rights to hold and receive land and obliged the government to facilitate land market transactions by improving the security of property rights and the titling and land registry process (Boucher, et al. 2005, 109).

In order to accomplish these goals, the government restructured and strengthened BANADESA, the Honduran agricultural development bank. The LMDSA was very successful in providing land titles. From 1994 to 2000, over 100,000 land titles were granted for parcels averaging 8 ha, while in the previous decade only 50,000 titles were given under the Agrarian Reform Law (Boucher et al 2005, 109).

Honduras began pursuing export-led growth in 1984 with the signing of the Caribbean Basin Initiative (CBI), the precursor to CAFTA. Before the CBI, non-traditional exports were valued at US$ 423 million for Honduras, but by 1993 they totaled US$ 1.3 billion. However, between 1985 and 1989 this sector experienced a near collapse that resulted in a shift of products. Prior to this Honduras specialized in cucumbers and tomatoes. However, market flooding in the cucumber industry and fruit fly infestations in the tomatoes resulted in the reduction of area planted in cucumbers and a complete collapse of the tomato industry in Honduras (Imbruce 2008, 72).

Asian vegetables got their start in the Dominican Republic in the 1960’s and experienced a 13% annual growth rate through the mid-1980’s. However, in the late 1980’s, pesticide residue on these exports was found to be above the US government’s maximum standard and the Food and Drug Administration (FDA) rejected 12.2% of all imports from the Dominican Republic in 1987 and 1988. The Asian vegetable sector was particularly hard hit with an estimated loss of US$ 2.5 million (Murray and Hoppin 1992, 598-599). This collapse of the oriental vegetable sector in the Dominican Republic coincided with the collapse of the tomato industry in Honduras. A joint venture between an Asian vegetable investor, a Honduran agronomist, and a Honduran coffee exporter resulted in the first Asian vegetable company in Comayagua. Initially, farmers were hesitant to plant these vegetables due to unfamiliarity with the crops and lack of trust in agro-corporations. But over time this industry proved to be stable and more farmers began growing oriental vegetables. By 2005 Honduras exported 47 million pounds of Asian vegetables (Imbruce 2008, 73).

CHAPTER TWO: METHODS

The data reported here were obtained during the summer of 2009 and focused on pesticide use in the Asian vegetable sector of the export market in Honduras. This study attempts to explore the impact of growing vegetables for export and the use of pesticides, and looks briefly at the forces which influence the decision to adopt, or not, integrated pest management (IPM) technologies by small farmers. Data were obtained during a collaborative investigation of the Department of International Development, University of Denver and the Honduran Agricultural Research Foundation (FHIA). FHIA is a private, apolitical non-profit organization that conducts agricultural research at six facilities in Honduras, including a variety of projects for the transfer of technologies to farmers. FHIA received funding in 2009 to extend their technical outreach in the Comayagua Valley, where the principle commercial produce are Asian vegetables, which include eggplant, okra, bitter melon, bottle gourd and cucumber. At the time of this study, FHIA was in the second phase of an extension project where farmers growing Asian vegetables at the time of the project within a given radius of the FHIA horticultural research center in Comayagua received field visits from the *ingenieros*, agricultural technicians. The first phase lasted 10 months and famers that demonstrated a willingness to heed the *ingenieros'* advice for pest management and still had vegetables growing on their land were selected for the second phase of the project where they continued to receive weekly visits from the *ingenieros* as well as pest management training classes.

Study Site

The Comayagua Valley is located just north of the city of La Paz and extends almost 37 km further north to the city of Siguatepeque (Figure 2). The elevation varies between 535 to 590m in the valley and just over 2,400m in the surrounding mountains. The mountains support forest and coffee growers, but most of the valley has been cleared for agriculture. The Pan-American Highway runs from Tegucigalpa, the capital of Honduras, through the Comayagua Valley to Puerto Cortés on the Atlantic Coast, giving farmers relatively easy access to national and international markets. The Caribbean Basin Initiative of 1984 and market access led to an increase in export agriculture in Honduras, and Comayagua Valley has become Honduras' primary source of fresh vegetables for export. The Department of Comayagua's population grew 42% from 1988 to 2001, mostly from internal migrations and high birth rate, but some have emigrated from El Salvador. Despite this growth only about 10% of the valley, 5,309ha, is planted in vegetables while over half is planted in grains mostly for auto-consumption and local and national markets (Imbruce 2008, 70-72). The specific farm locations within this Valley were collected using a handheld Garmin etrex GPS unit.

Figure 2: Map of the department of Comayagua, Honduras (modified from www.geographic.net/america/pictures/honduras-map)

Subjects

Asian vegetable farmers in the Comayagua River Valley in central Honduras were selected for inclusion in this study. Two FHIA *ingenieros* visited farmers weekly to diagnose pest problems and make suggestions of treatments (both chemical and non-chemical). The initial contact with farmers for this study was provided by the *ingenieros*. After initial contact, a snowball sampling method was used to meet other farmers, which ultimately resulted in a sample size of N = 43.

Design

The specific aims of this study were to survey the local farming population to establish the demographic characteristics of the region and statistically evaluate how these details relate to adoption of IPM technologies. The survey design was based in part on an earlier study done in the area (Hamilton and Fischer 2003), modified for local crops and chemical use based on conversations with farmers and *ingenieros*. The questionnaire included four sections which covered farm size and ownership, crops grown, chemicals used the week of the interview and other pest management practices employed by the farmer. The survey also included questions about the market, the cost of chemicals and the price of produce (for a complete list of the survey questions, refer to Appendix 1).

Data Analysis

Prices for specific products were provided by the farmers or in some cases the *ingenieros*. To account for missing price data, a general price list was established by averaging all prices within each category, so all prices reported for a particular crop or chemical were averaged and used to calculated a farmers input and output costs. To determine the demographics for the study population descriptive statistics were applied to the data for the amount of land farmers have access to, type and number of crops, irrigation systems, amounts of chemicals used per week, and pest management techniques used. The data on integrated pest management (IPM) use was collected in a yes or no survey format for 16 different techniques, as follows: use of certified seeds, disinfecting the soil before planting, rotating crops, intercropping, use of “good” insects, monitoring fields before applying chemicals, consulting technicians, rotating pesticides, use of fixed traps, mobile traps, barriers, or trapping plants, wearing protective clothing, application of lime, weeding and disposal of residuals after harvest. Logistic regression analysis was run on the integrated pest management practices used by farmers with the IPM data as the dependent variables and the individual farm characteristics as the independent variables. Logistic regression tests the probability of independent variables based on binomial dependent variables. In other words, logistic regression allows one to determine the probability that a farmer owning X amount of land will use a certain IPM technique.

Geospatial Analysis

A geodatabase of the Comayagua Valley was created using ArcGIS software. Data on the roads and cities of Honduras were downloaded from ArcGIS online (http://resources.esri.com/arcgisdesktop/index.cfm?fa=content&tab=Layers). The GPS site data collected during the study period were downloaded from the handheld Garmen unit into longitude/latitude format for use with ArcGIS, to create a map illustrating farm distribution. Using the farm location, roads and city data, a network database was created. Using this network, routes from the farms to the nearest urban center, Comayagua, were calculated. The distance was given in total kilometers from the fields to market distribution centers. Calculating distances is an important aspect of development work. Distances to markets, water sources, health center, analysis of livelihoods and many other locations are important in planning effective development projects. Using the limited data available for this study, a model was created to calculate distances in the field for future studies and development projects.

CHAPTER THREE: RESULTS

Forty three farmers were interviewed, 30 of whom were affiliated with FHIA. In addition, two farmers (one with FHIA and one independent) did not grow Asian vegetables at the time of the survey and were excluded from further analysis. Only 12 farmers were members of a farmer’s cooperative or group. In addition, 36 farmers had participated in pest management classes, which include classes on chemical use, while 35 farmers had participated in classes specifically related to IPM (Table 4).

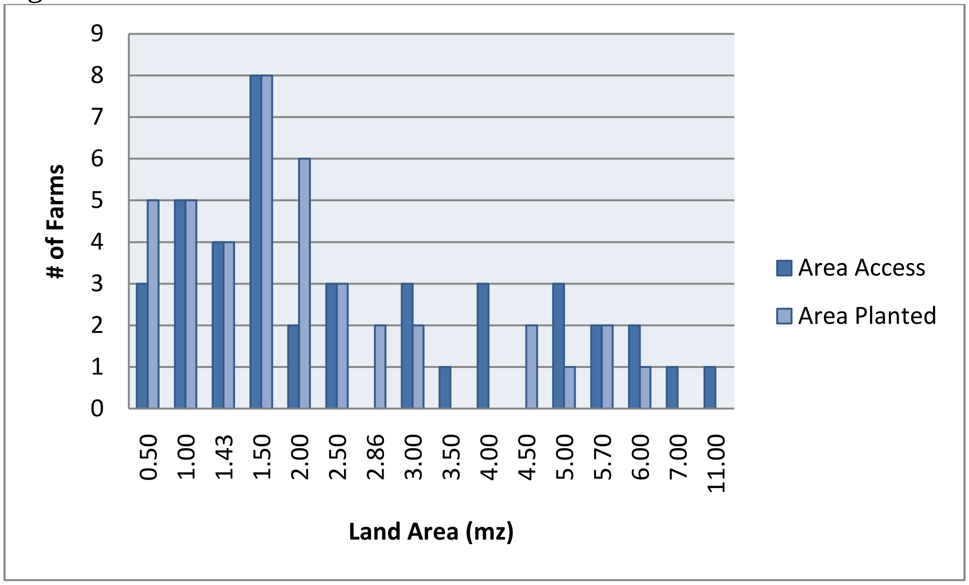
Table 4: Membership and classes

	Yes	No
Affiliated with FHIA	29	12
Members of a Cooperative	12	29
Participated in pest management classes	36	5
Participated in IPM classes	35	6

Land Use and Access

On average, farmers had access to 2.85 *manzanas* (a local measurement equal to about 0.699ha, abbreviated *mz*). The smallest area of land farmers had access to was 0.5*mz* and one farmer had 11*mz*. However, most farmers had between 0.5 and 2.0*mz* (22 farmers, 53.7%), with the highest frequencies occurring at 1.5*mz* (Figure 3). Farmers with 2*mz* or less typically planted all of the land they had access to, while farmers with 2.5*mz* or more would only plant a portion of their land at any given time (Figure 3).

Figure 3: Land Access



Seven different categories of land access were observed: rented, jointly owned (as part of a family or group), bought, inherited, rented and bought, rented and inherited, bought and inherited. Most farmers either rented (31.71%) or inherited (39.02%) their land (Table 4). All farmers in this study had access to water and employed some form of irrigation. Farmers employed three different types of watering systems: pump fed gravity (31.71%), drip irrigation (60.98%), or a combination of these two (7.32%) (Table 5). In most cases water was pumped from a nearby stream or river and fed into canals for the gravity powered system or into barrels and then pumped out through hoses for drip irrigation.

Table 5: Land ownership and watering systems employed by farmers

Land Ownership	**# of farmers**	**Water System**	**# of farmers**
Rented	13	Rain	0
Part of the Family/group	3	Gravity	13
Bought	4	Drip Irrigation	25
Inherited	16	Combo - gravity and drip	3
Rent and bought	0		
Rent and inherited	2		
Bought and inherited	3		

Most farmers with access to 1.43*mz* (1 ha) or less only grew one crop, there are two exceptions to this: famer 19 had 1.43*mz* but grew eggplant and beans for auto consumption and 43, had 1*mz* and grew two varieties of Asian vegetables. However, the reverse is not true; farmers with access to more than 1.5*mz* did not always grow multiple crops. Table 6 shows how much total land each farmer in the study had access to and the number of Asian vegetables and other crops grown on that land.

Table 6: Number of crops grown:

Farmer	Area (mz)	# of Asian Vegetables	# of other crops	farmer	Area (mz)	# of Asian Vegetables	# of other crops
1	1.5	2		22	1.43	1	
2	1.5	1	1	23	5	2	3
3	1.5	1	1	24	1.5	1	
4	6	3	2	26	7	1	1
5	5	1	3	27	4	1	1
6	0.5	1		28	6	1	1
7	0.5	1		29	1	1	
8	1	1	2	30	3	1	2
9	0.5	1		31	1.5	1	
10	4	1	1	32	3	1	
11	11	3	1	33	1.43	1	
12	4	2	1	34	1.5	1	1
13	3	1	1	35	1	1	
14	5.75	1	1	37	2.5	1	1
15	2	1		38	1.43	1	
16	1	1		39	2.5	3	
17	3.5	1	1	40	1.5	2	
18	2.5	2		41	1	1	
19	1.43	1	1	42	1.5	2	
20	5.71	1		43	1	2	
21	5	1	1				

The Asian vegetables grown in this region include eggplant (four varieties, which for the purpose of this study were divided into two categories: Chinese eggplant and Other, which included Japanese, Hindu and Thai eggplant), bottle gourd, okra (two varieties), bitter melon (two varieties) and cucumber. The most common vegetable grown is Chinese eggplant with 20 farmers (48.8%) growing this crop. The other three varieties of eggplants were only grown by 7 farmers (17.1%). Bottle gourd was grown by 7 farmers (17.1%). The two varieties of bitter melon were grown by 8 farmers (19.5%). The two varieties of okra were grown by 5 farmers (12.2%) and cucumbers were grown by 4 farmers (9.8%) (Table 7). However, only 15 farmers grew only one crop. Most farmers (20) grew two crops; the other eight farmers grew between three and five different crops. Farmers that grew more than one crop frequently grew subsistence crops, such as maize and beans, or other cash crops for local markets, such as plantains, rice, yucca, papaya, mango and passion fruit (Table 7).

Table 7: Produce

Asian Vegetables	# of Farmers	% of Farmers	Other Crops	# of Farmers	% of Farmers
C. Eggplant	20	48.8	Maize	13	31.7
Other Eggplant	7	17.1	Beans	5	12.2
Bottle Gourd	7	17.1	Yucca	1	2.4
Bitter Melon	8	19.5	Plantains	3	7.3
Okra	5	12.2	Rice	1	2.4
Cucumber	4	9.8	Papaya	3	7.3
Other	28	68.3	Mango	1	2.4
			Passion fruit	1	2.4

Farmers sold their vegetables to one of four exporters: Inversiones Mejia, Vasquez Agroindustrial, Agro Exporters of Vegetables Dominguez, or Exveco, SA. However, information on these companies is limited. Farmers reported the company to which they sold their produce and the price they received per box of produce (1 box = 30-35lbs). However, actual price data from the companies themselves was not obtained. Table 8 lists the prices reported by farmers for these companies, however, not all the data for every crop is available. Vegetables were typically harvested 2-3 times a week. The average number boxes farmers harvested per *manzana* are reported in Table 9. None of the farmers in the study were currently harvesting bottle gourd so the data for that vegetable is missing. However, the number of boxes harvested does not necessarily correlate with the number of boxes the export company would buy from the farmer, which data was not obtained in this study.

Table 8: Crop price from export companies (US$ per box, or 30-35lbs)

Produce	Mejia	Dominguez	Basquez	Exveco
Chinese Eggplant	5.19	5.37	4.82	5.75
Thai Eggplant	5.56			6.11
Hindu Eggplant	5.19			5.47
Japanese Eggplant	4.68			
Bottle Gourd	5.83	7.06		
Chinese Bitter Melon	4.90	4.44	4.72	
Hindu Bitter Melon	5.02	4.86		
Chinese Okra	3.56	4.67		
Thai Okra	3.33	4.59		3.33
Cucumber	5.04	5.00		5.97

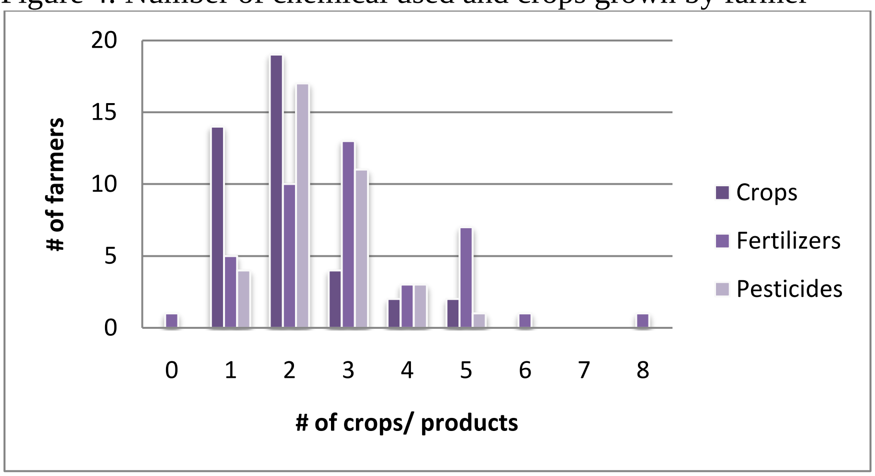
Table 9: Crop yields per *manzana*

Produce	# of boxes per mz per harvest	# of harvests per week
Chinese Eggplant	70	2
Thai Eggplant	63	2
Hindu Eggplant	94	3
Japonese Eggplant	37	3
Bottle Gourd		3
Chinese Bitter Melon	45	2
Hindu Bitter Melan	40	3
Cinese Okra	46	3
Thai Okra	45	3
Cucumber	44	3

Pesticide and Fertilizer Use

The chemical schedules farmers used were different for fertilizers and pesticides. Most farmers used a set number of fertilizers and rotated them on a biweekly calendar. Pesticides on the other hand were used on a weekly basis and rotated regularly depending on the pests present in the field or on the recommendations of technicians. As a result, data were collected based on the biweekly use of fertilizes and the weekly use of pesticides. Farmers applied between 0 and 8 different fertilizer products per month, with an average application of 3 different products. They applied between 1 and 5 different pesticides products per week (Figure 4). So the total average number of chemicals applied per month was 5.6, with a minimum of 2 and a maximum of 12.

Figure 4: Number of chemical used and crops grown by farmer



Chemicals were applied to the fields in six different ways: planting a small amount of chemical at the base of each plant, spraying, mixed in with the water and applied through drip irrigation, a combination of planting and irrigation, a combination of planting and spraying, or a combination of spray and irrigation. Most fertilizers were applied by planting the chemical at the base of the plant (41.46%) or by mixing the chemical with water and running it through the drip irrigation system (39.02%). Pesticides were only applied by backpack sprayers; however, one farmer used a combination of backpack sprayer with planting chemicals at the base of the plants. The farmers in this study spent between 0 – 19094.89 *lempiras* (US $0-1060.83), with a median of 2780.26 *lempiras* (US $154.46) and an average of 4165.97 *lempiras* (US $231.44) bi-weekly on fertilizers. In addition, they spent between 54.78-8178.34 *lempiras* (US $3.04-454.35) weekly on pesticides with a median of 908.67 *lempiras* (US $50.48) and an average of 1961.41 *lempiras* (US $69.00) (Table 10).

Table 10: Chemical Price List

Fertilizers		Pesticides	
Product	**Price**	**Producto**	**Gastos**
0-64-7	3600 lp/quint*	**Acaristop**	1013 lp/L
7-12-88	3600 lp/quint	**Acaromic**	1875 lp/L
12-24-12	412.67 lp/quint	**Acrobat**	900 lp/kg
15-15-15	385.83 lp/quint	**Actara**	4123.34 lp/kg
18-46-0	583.93 lp/quint	**Amistar 50 WP**	4100 lp/kg
20-20-20	1600 lp/quint	**Antracol WP70**	106.67 lp/kg
Boro	260 lp/quint	**Bellis**	2600 lp/g
Cacetalera	403.75 lp/quint	**Bravo Ultrex**	312.5 lp/L
Calcio	661.43 lp/quint	**Captan**	260 lp/kg
Fosforo	1336 lp/quint	**Curion**	910 lp/L
KCl	755.63 lp/quint	**Deacinon AG 60 EC**	330 lp/L
Magnesio	498.33 lp/quint	**Decis**	950 lp/L
MAP	1304.29 lp/quint	**Derosal**	420 lp/L
MAX	1234.5 lp/quint	**Dictane**	280 lp/kg
N. de Amonio	410 lp/quint	**Dipel**	NA
N. de Potasio	1310 lp/quint	**Dorado 92 WP**	120 lp/kg
Nitrojeno	416.75 lp/quint	**Karate zeon**	1045 lp/L
Potasio	881.6 lp/quint	**Krisol**	1777.78 lp/kg
S. de Amonio	285 lp/quint	**Mancozeb**	140 lp/Kg
S. de Magnesio	600 lp/quint	**Mitac**	216.27 lp/L
Suero	100 lp/quint	**Monarca 11.25 SE**	800.77 lp/L
Suformat	1400 lp/quint	**Murralla 10 EC**	540 lp/L
Trato de Amonio	370 lp/quint	**Nemacur**	280 lp/L
Urea	356.47 lp/quint	**Newmectin**	1824.29 lp/L
Zinc	260 lp/quint	**Phyrimetha 25EC**	600 lp/L
		Phyton	1200 lp/L
		Plural	1920 lp/L

Fertilizers		Pesticides	
Product	**Price**	**Producto**	**Gastos**
		Previcur	650 lp/L
		Proclaim 5 SC	3006. 45 lp/Kg
		Regent	3000 lp/L
		Ridomil Gold Mz	200 lp/kg
		Rienda	585 lp/L
		Siper	517.77 lp/L
		Silvacur combi	1288 lp/L
		Spintor 12SC	4000 lp/L
		Sunfire 24SC	2111 lp/L
		Talonil	300 lp/L
		Tamaron	NA
		Thiodan 35 EC	150 lp/L
		Verla	2300 lp/L
		Vertimec 1.8 EC	3666.67 lp/L
		Vydate 24 L	650 lp/L

**quint* is short for *quintal* which is a local measure indicating 100lbs

There were 25 different fertilizers and 43 different pesticides found to be used in this region by these farmers. Of the pesticides, none were found to belong to WHO classification IA, Extremely Hazardous however; four pesticides were found to belong to WHO classification IB, Highly Hazardous. Of these four, Curion was the most commonly used, with three different farmers reporting having used this insecticide in the week of the interview. 38.71% (12) of the record pesticides belonged to WHO classification II, Moderately Hazardous. Monarca 11.25 SE was the most commonly used pesticide in this category with 12 recorded uses. Only two pesticides used by farmers belonged to WHO classification III, Slightly Hazardous, and 13 (or 41.9%) were regarded by WHO as "unlikely to present acute hazard in normal use." In addition, 11 of the chemical were not registered by WHO (Table 11).

Table 11: Pesticide List

Pesticides	Biocide Type	Active Ingredient	Uses	WHO Class	Mechanism of action
Newmectin	Insecticide	Abamectin	8		Chloride channel activators
Vertimec 1.8 EC	Insecticide	Abamectin	3		Chloride channel activators
Amistar 50 WP	fungicide	Azoxystrobin	3	V	respiration inhibitors
Dipel		Bacillus thuringiensis	1	V	
Captan		Captan	1	V	Multiple sites of action
Derosal	fungicide	Carbendazim	2	V	
Sunfire 24SC	Insecticide	Chlorfenapyr	5	III	uncouples oxidative phosphorylation via disruption of proton gradient
Talonil	fungicide	Chlorothalonil	2	V	
Bravo Ultrex	fungicide	Chlorothalonil	4	V	
Acaristop	Insecticide	Clofentezine	1	V	
Phyton		Copper sulfate pentahydrate	1	III	Multiple sites of action
Phyrimetha 25EC	Insecticide	Cypermethrim	4	III	Sodium Channel modulator
Decis	fungicide	Deltamethrin	1	III	Sodium Channel modulator
Deacinon AG 60 EC	Insecticide	Diazinon	1	III	Acetylcholinesterase inhibitor
Acrobat	fungicide	Dimethomorph, chlorothalonil	1	V	Dimethomorph: cell wall disposition
Proclaim 5 SC	Insecticide	Emamectin benzoate	2		Chloride channel activators
Thiodan 35 EC	Insecticide	Endosulfan	2	III	Gated chloride channel antagonists
Nemacur		Fenamiphos	1	II	
Regent	Insecticide	Fipronil	1	III	Gated chloride channel antagonists
Plural		Imidacloprid	1	III	Acetylcholine receptor
Rienda	Insecticide	Imidacloprid	4	III	Acetylcholine receptor
Karate zeon		Lambda cyhalotrin	4	III	Sodium Channel modulator
Ditane	fungicide	Mancozeb	3	V	Multiple sites of action
Mancozeb	fungicide	Mancozeb	4	V	Multiple sites of action
Ridomil Gold Mz	fungicide	Metalaxyl-M, Mancozeb	1	IIII	Metalaxyl - disrupts fungal nucleic acid synthesis
Vydate 24 L		Oxamyl	1	II	Acetylcholinesterase inhibitor

Pesticides	Biocide Type	Active Ingredient	Uses	WHO Class	Mechanism of action
Curion	Insecticide	Profenofos, Luferuron	3	III	Lufenuron: inhibitor of chitin biosynthesis
Previcur	fungicide	Propamocarb	1	V	cell membrane permability
Antracol WP70	fungicide	Propineb	4	V	
Bellis	fungicide	Pyraclostrobin	1		respiration inhibitors
Spintor 12SC	Insecticide	Spinoza	1		
Dorado 92 WP		Sulfur	1	V	
Silvacur combi	fungicide	Tebuconazole, Triadimenol	1	IIII	Both: De-methylation Inhibitor
Monarca 11.25 SE	Insecticide	Thiacloprid, beta-cyfluthrin	12	III	Thiacloprid: Acetylcholine receptor beta-cyfluthrin: Sodium channel modulator
Murralla 10 EC		Thiacloprid, cyfluthrin	2	III	Thiacloprid: Acetylcholine receptor Cyfluthrin: Sodium channel modulator
Actara	Insecticide	Thiametoxan	3		
Krisol	Insecticide	Thiodicarb	3	III	Acetylcholinesterase inhibitor, neurotoxin
Acaromic			2		
Cabretane			1		
Mitac			1		
Tamaron			1		
Verla			1		

Analysis of IPM Practices

The survey included sixteen yes or no question related to IPM techniques used by the farmers. Farmers were asked whether they practiced the following: use of certified seeds, disinfection of soil prior to planting, rotation of crops, diversifications of crops, use of “good” insects, monitor crops regularly for pests, consult regularly with a technician, rotation of chemicals (especially pesticides), use of fixed traps, use of mobile traps, use of trapping plants, use of protective clothing, weeding, and disposal of remnants after harvest. The results are shown in Table 12.

Table 12: IPM use

IPM Practices	# of Farmers Yes	No
Used certified seeds	40	1
Disinfected the soil prior to planting	17	24
Rotated crops	40	1
Diversified Crops	3	38
Used "good" bugs	1	40
Monitored crops for pests	35	6
Consulted technicians regularly	38	3
Rotated chemicals	40	1
Used fixed traps	15	26
Used mobile traps	0	41
Used barriers	20	21
Used trapping plants	1	40
Wore protective clothing	37	4
Used lime	16	25
Weeded fields	40	1
Disposal of remnants	36	5

Most farmers bought seeds or seedlings from the export company, FHIA or another greenhouse. Chinese eggplant, in particular, was always bought as graphed seedlings. This variety of eggplant could successfully be graphed onto a local plant from same family. This process allowed the plant to produce fruit for up to a year at which point farmers would prune the plant back to the stem and graphed bud. The plant could then re-grow from that point and produce for up to another six months. Farmers consider this a huge advantage since regular Chinese eggplant normally produces only 4-5 months, even though graphed seedling cost about 3 *lempiras* per plant. However, farmers preferred to buy seeds and, in some cases, seedlings for all types of vegetables, rather than save seeds from one year to the next.

Seventeen farmers disinfected the soil prior to planting crops to reduce the likelihood that there were any lingering diseases in the soil from previous crops. However, this usually involved spaying some sort of fungicide or other biocide on the soil a day or two before planting. Crop rotation is a common IPM practice. Since different crops extract different nutrients from the soil and some even replenish certain nutrients (like the nitrogen fixing legumes), crop rotations slows down the nutrient depletion process allowing farmers to use the same land for longer periods of time. In Comayagua, farmers frequently rotated Asian vegetables with subsistent crops such as corn or beans. Diversification is the process of inter-cropping or planting more than one crop in a field. This is done for the same reason as crop rotation, only the affects are more immediate, for example you could plant a nitrogen fixer in one row and a nitrogen consumer in the next. However, this process is more labor intensive and some crops should not be planted together. As a result, only 3 farmers in Comayagua said they used this practice.

Predatory or “good” bugs can be used to kill off pest populations however; no one in this study had ever used this practice. The practice of monitoring fields is promoted so that farmers are constantly aware of what pest problems are present and apply pesticides that directly target that pest and not just generic biocides. This reduces the number of highly hazardous chemicals farmers use and the number of time they apply pesticides since theoretically they won’t apply chemicals if there is no problem. Most farmers in this study spent a significant amount of time in their fields and had participated in pest management classes so they were constantly watching what was going on in their fields. Consulting technicians is important especially when dealing with a new pest or if the farmer notices that pests are becoming resistant to the chemicals or management techniques that farmers is using. Most farmers in this study had relatively easy access to technicians either through FHIA and organizations like FHIA or through the export companies. Rotating pesticides keeps pests from becoming resistant to a particular chemical;

therefore farmers can spray fewer times or use less toxic chemicals. This was one of the most common practices of pest control, however observations indicate that farmers still applied pesticides at least once, but usually twice a week.

Fixed traps were placed around the field to catch moths or other bugs before they attacked or laid eggs in the crops. The most common fixed trap seen was a plastic bottle cut in half with molasses. Mobile traps were observed in Guatemala in snow pea production, but no one in Honduras was seen to use this technique. Planted barriers help prevent wind erosion and can when combined with trapping plants reduce insect invasion into the crops. However, while almost half of the farmers used barriers they planted them with millet, corn or king grass, none of which having trapping or deterring properties.

Protective clothing has obvious advantages of protecting the farmer from pesticide exposure. Clothing farmers said they used when spraying included rubber boots, handkerchief, mask, glasses, overalls, gloves, and long sleeve shirts (Table 13). Lime was used to deter fungi from attacking the roots. Farmers would periodically plant a small amount at the base of their crops. Getting rid of weeds reduces habitat for pests and reduces competition for nutrients in the soil. This can be accomplished manually with hoes, but this labor intensive and most farmers used herbicides. Though details about herbicides were not part of this study, the Dirty Dozen herbicide, paraquat was seen in several fields and trash piles next to the fields. Once the harvest was done and the plants had died, farmers used a variety of techniques to get rid of the remains, such as burning the crops in the field, cut the plants and the burn them, cut the plants and remove from the field, and plow into the soil (Table 14).

Table 13:Protective clothing used by farmers

Clothing	# of farmers
Rubber Boots	32
Handkerchief	2
Mask	18
Glasses	7
Overalls	12
Long sleeve shirt	3
Gloves	4

Table 14: Disposal methods

Disposal methods	# of farmers
Cut and burn	5
Burn	12
Plow into soil	15
Cut and remove	3
Leave in the field	1

Logistical regression was run on the IPM practices in order to identify correlations between a farmers use or disuse of a given practice and factors that may have influenced this decision. Practices which were practiced by all the farmers or none were not tested. IPM practices that were not used by any farmer included the use of “good” bugs, the use of a mobile trap and the use of predatory or bug deterring plants. In addition, IPM practices that were not used by enough farmers for analysis included the use of certified seeds, crop rotation, pesticide rotation, weeding, crop diversification, regularly consulting with a technician, the use of protective clothing, or the disposal of the plant after harvest. Logistical regression was run on disinfecting soil, monitoring fields for pests, use of fixed traps, use of barriers, and use of lime. Variables used to analyze the adoption of these practices included total area access, area planted, total number of crops planted, amount of fertilizers and pesticides, total number of chemical used, and potential income as the variables of influence. These variables were chosen because they reflect the farmer’s economic situation (inputs and potential outputs) that may influence his decision about whether or not to adopt certain IPM techniques. Increasing the number of IPM strategies employed in the fields could reduce a farmers need to buy chemicals, reducing the cost of production. However, labor intensive IPM strategies, such as the use of mobile traps which have to be moved over the crops on a regular basis, may require more input costs in the form of labor payments.

Initially all variables were tested individually against the IPM techniques. These tests resulted in no significant results. Afterwards factor analysis was done in order to identify any underlying construct between the variables. The factor analysis returned an eigenvalue of 3.927 for the first principle and an eigenvalue of 1.117 for the second principle (Figure 5). This indicated that some variables with similar values in “principle one” of the factor analysis have an underlying construct. These variables include: the total area to which a farmer has access, the area actually planted with Asian vegetables and total number of chemicals used per week. In order to explore these constructs, logistic regression was rerun on the IPM techniques mentioned previously, but this time these three variables were used simultaneously as the independent quantitative variables. When this was done most of the tests returned no significant p-values, with three exceptions. The regression run on the use of fixed traps and the use of barriers, resulted in three significant p-values (< 0.05). In the regression on the use of fixed traps the total area variable had an odds ratio of 0.296 with a p-value of 0.0479 and a 95% Wald confidence interval of 0.089-0.989. The test on the use of barriers resulted in an odds ratio of 0.143 for total area with a p-value of 0.0403 and a 95% Wald confidence interval of 0.022-0.918. In the same regression on barriers, the area planted gave an odds ratio of 10.098 with a p-value of 0.0310 and confidence interval of 1.236-82.498 (Table 15). So, for every unit (1 *manzana*, or 0.7ha) increase in area the farmer has access to there is 0.67% likelihood that the farmer will use fixed traps. The same is true for barriers; for every unit increase in area that farmers have access to there is

0.857% likelihood that the farmers will employ the use of barriers on their land. However, for every unit increase in area planted there is 10.1% likelihood that the farmer will use barriers.

Figure 5: Scree plot, eigenvalues

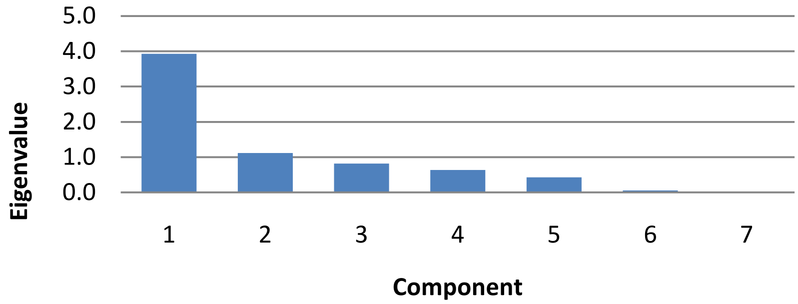


Table 15: Logistic regression

Disinfecting the Soil			Wald's Confidence
IPM technique	Odds ratio	p-value	Interval
Total area	0.718	0.1922	0.436-1.181
Area planted	0.912	0.7962	0.451-1.841
Chemical price	1.138	0.5268	0.763-1.696
Monitoring Crops			Wald's Confidence
IPM technique	Odds ratio	p-value	Interval
Total area	1.120	0.7776	0.510-2.460
Area planted	0.330	0.2355	0.053-2.063
Chemical price	0.8427	0.5259	0.460-1.487
Fixed Traps			Wald's Confidence
IPM technique	Odds ratio	p-value	Interval
Total area	0.296	0.0479	0.089-0.989
Area planted	2.834	0.1374	0.717-11.201
Chemical price	1.389	0.2259	0.816-2.363
Barriers			Wald's Confidence
IPM technique	Odds ratio	p-value	Interval
Total area	0.143	0.0403	0.022-0.918
Area planted	10.098	0.0310	1.236-82.498
Chemical price	0.708	0.1489	0.443-1.131
Use of Lime			Wald's Confidence
IPM technique	Odds ratio	p-value	Interval
Total area	0.553	0.0573	0.301-1.018
Area planted	1.297	0.2556	0.828-2.031
Chemical price	1.497	0.3145	0.682-3.284

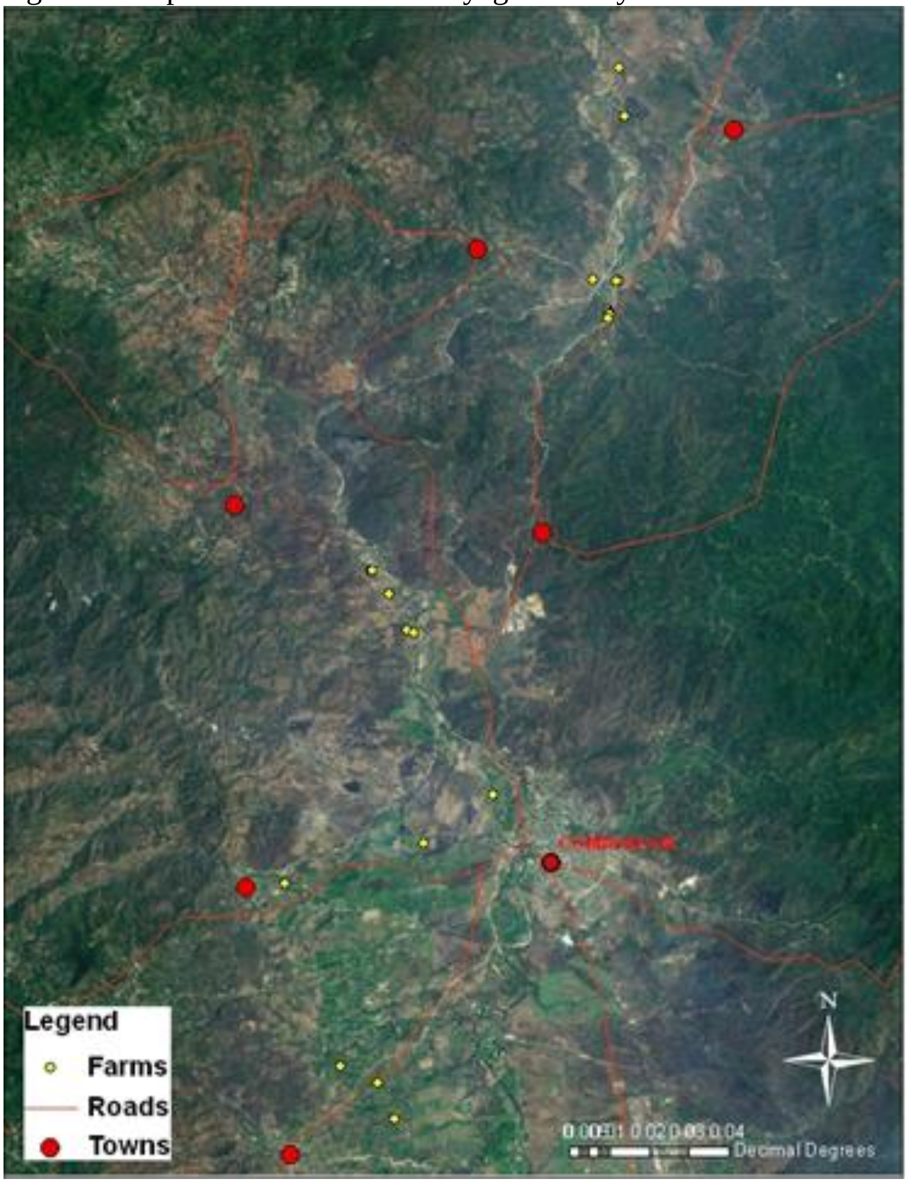
Geographical Analysis

GPS data could only be collected for 20 farms due to difficulties of connecting to satellites in some locations or in some weather conditions (Map 1). Unfortunately there is not enough GPS data to for statistical analysis to determine if distance is a factor decision making for types of crops grown, amounts of chemicals used, or IPM strategies employed. The GPS data was to create a model for calculating distances in remote areas. Although road and city GIS data are available for Honduras, few of the farms in this study were located on paved roads and the Honduras data set did not include gravel or dirt roads. For this analysis, distance from the farm to the nearest road was calculated using “point to near feature” tool in ArcGIS and the intersection was marked on the road. Then a network was created using the roads layer. In that network, distances could be calculated from the farms to roads intersections to Comayagua. Then the two distances (farm to road intersect and road intersect to Comayagua) were added together generate the total farm to market distance. The farms in this study were located between 2.9 km and 26.5 km away from Comayagua, the primary market and distribution center in the area. The average distance was 13.8 km with a median of 10.73 km from the town. Farmers that were affiliated with FHIA averaged 15.3 km (median of 17.4 km) from Comayagua and 0.93 km (median of 0.81 km) from a paved road, while farmers that weren’t part of FHIA’s project were located an average of 11.89 km (median of 10.71 km) from Comayagua and 0.96 km (median of 1.29 km) from a paved road. Farmers that were members in a local cooperative were located between 4.89 km and 24.78 km from Comayagua, with an average of 13.59 km (median= 10.19km).Those that weren’t part of a cooperative were located between 2.97 km and 26.5 km from the town with an average of 13.89 km (median =10.86 km). Classes on pest management and IPM were attended by the same farmers. Those that attended were located between2.97 km and 26.5 km from Comayagua with an average of 13.48 km (median = 10.75 km). Only three farmers didn't participate in classes and they were located between 9.72 km and 19.08 km from Comayagua (Table 16).

Table 16: Distances to Comayagua (km)

farmer	Distance to paved road (km)	Distance to Comayagua (km)	FHIA associate	Coop Member	Pest Class	IPM Class	Area access	Area Planted	# of Crops
1	0.11	17.44	yes	no	yes	yes	1.5	1.5	2
11	1.23	10.86	yes	no	yes	yes	11	3	3
12	0.16	9.17	yes	yes	yes	yes	4	3	3
15	0.43	18.75	yes	no	yes	yes	2	2	1
16	0.39	18.75	yes	yes	yes	yes	1	1	1
17	1.03	19.08	yes	yes	no	no	3.5	2.86	2
22	2.00	24.78	yes	yes	yes	yes	1.43	1.43	1
23	2.64	26.50	yes	no	yes	yes	5	5	5
24	0.84	4.89	yes	yes	yes	yes	1.5	1.5	1
25	0.81	10.19	yes	yes	yes	yes	4	1	1
27	0.55	8.25	yes	yes	yes	yes	4	1.25	2
33	0.24	17.75	no	no	no	no	1.43	1.43	1
34	0.14	17.60	no	no	yes	yes	0.5	1.5	2
35	0.15	17.59	no	no	yes	yes	1	0.5	2
37	1.51	9.72	no	no	no	no	2.5	0.5	1
38	1.42	9.47	no	no	yes	yes	1.43	1.43	2
39	1.29	10.41	no	no	yes	yes	2.5	2.25	2
40	1.59	10.71	no	no	yes	yes	1.5	1.5	1
41	1.64	10.75	no	no	yes	yes	1	1	3
42	0.63	2.97	no	no	yes	yes	1.5	1.5	2

Figure 6: Map of farms in the Comayagua Valley



CHAPTER FOUR: DISCUSSION

Current Situation

This study took place over two months during the summer of 2009. On June 28, 2009, two weeks after the study started, Honduran President Manuel Zalaya was forcibly exiled by the military, acting under orders from the Supreme Court. This led to what has come to be considered the 2009 Constitutional Crisis of Honduras, precipitated by the scheduling of a public opinion poll on a potential referendum to convene a constituent assembly. According to President Zalaya's opponents, this was an attempt to eliminate presidential term limits. Although President Zalaya and his supporters insist he was just attempting to modernize the Honduran Constitution, this was opposed by the legislative branch and ruled unconstitutional by the Honduran Supreme Court. The night before the poll was to have taken place, the Honduran military stormed the presidential residence, confiscated the ballots and put the President on a plane to Costa Rica. By Monday, the Speaker of the Congress Roberto Micheletti had been sworn in as Interim President, a position which he held until the November elections. This resulted in a standoff between Zalaya and Micheletti, with mass demonstrations in Tegucigalpa and San Pedro Sula and road closings of major trade and bus routes around the country, including the Pan American Highway that runs through the Comayagua Valley. Micheletti responded by issuing a "state of exception" suspending civil liberties throughout the country. With time, it became apparent that there was not going to be a quick or easy solution to the political standoff. International organizations and countries began applying political and economic pressure for the Micheletti government to stand down. USAID pulled a significant amount of funding from Honduras and the US government put restrictions on the import of Honduran goods.

For the most part, Comayagua was calm and farmers continued their work undisturbed. The primary impact on this study resulted from the restrictions on movement throughout the country. The road closings made it very difficult to get to the farms, and it remained possible largely because the *ingenieros* frequently knew ways around the peasant manifestations and road blocks. However, it took longer to reach the farms, limiting the number of farmers that could be interviewed on any given day.

In addition to these logistical difficulties, this study took place during the agricultural low months in Honduras. Honduras has a semitropical climate and can grow produce year round; however, production in the United States, which is the primary importer of Honduras' agricultural products, is more cyclical. Increases in fruit and vegetable production during the summer months in the US results in less demand for imports. As a result, most of the farmers were between cycles, clearing and preparing fields or growing subsistence crops, while waiting for the US import markets to pick up. These farmers were not interviewed for this study, which included only those farmers growing Asian vegetables during the study period. The political climate, the market cycle and the reliance on *ingenieros* to move through the countryside results in a small sample population for this study, and biased toward farmers that were part of the second round of the FHIA project (29 of 41 farmers, 70.7%).

Land Use and Access

Despite recent trends in urbanization, over 60% of the Honduran population still lives in the rural areas and most of this population is involved in agriculture. Non-traditional agricultural exports (NTAEs) have been promoted in the Central American region since the 1960's as a development strategy targeted towards rural peasant populations. NTAEs are typically labor intensive and have higher value on the market than traditional crops providing higher income for farmers and work for people with no access to land. Previous studies have found that most NTAE farmers have access to less than a hectare of land. Hamilton and Fischer (2003) found that 69% of NTAE farmers in Guatemala had access to less than a hectare of land with a total range of 0.30-32.6 ha. Imbruce (2008) found that in Honduras NTAE farmers had access to between 0.35-25.2 ha. This study found a smaller range (0.35-7.69 ha) of land access due to the smaller sample size, however it is within the ranges reported in these other studies. A slightly different land access pattern was observed here where 29% of the sample population only had access to 1 ha or less, whereas in Guatemala that figure is much higher.

The study in Guatemala revealed that even the smallest farmers planted only part of their land with NTAEs, with the largest percentage of their land dedicated to subsistence crops. This study found the opposite in Honduras; the smallest farmers were the most likely to plant 100% of their land with vegetables for export, while farmers with greater access to land planted smaller percents of the land in vegetables. In Honduras, farmers tended to favor a production cycle where they would plant an Asian vegetable, which typically had a 6 month cycle, and then replace it with a subsistence crop, like corn, which has a 3 month cycle, instead of growing both NTAEs and subsistence crops at the same time. However, some of the smallest farmers would rotate crops between the different NTAEs since they had higher return rates choosing not to plant subsistence crops at all.

In terms of ownership and rental patterns this study supports the findings of Valerie Imbruce for this region. However, farmers in this study, on average, grew only 1 Asian vegetable where Imbruce found a mean of 2 vegetables. Chinese eggplant was the most common NTAE produced in this region. Grafted Chinese eggplant has a significantly longer production cycle is one of the highest value vegetables on the market, making it a top preference for farmers.

Pesticide and Fertilizer Use

Despite giving farmers a higher return for their land, NTAEs are not without problems. NTAEs are exactly what their name implies – not traditional or local. These crops do not grow naturally in the environments into which they are introduced and therefore do not always have the defense mechanisms necessary to combat local pests. This can result in heavy dependence on chemical use by NTAE farmers, which can negatively impact the health and environment of the rural population. It can also lead to resistance within pest populations to certain pesticides or rejection by the US market for failure to maintain maximum residue levels on imports which can result in a collapse of the industry, as happened to the Honduran tomato industry in the 1980s.

The farmers in this study had a fairly intensive chemical schedule for fertilizers and pesticides. While 39% of the farmers applied fertilizer using a drip irrigation system, which has been shown to reduce the amount of run-off contamination, 41.5% planted a small amount at the base of each plant. Chemicals applied in this way are easily washed away into rivers and streams. Pesticides were applied using a backpack sprayer. Farmers would only occasionally use protective clothing, the most common being boots, and a handkerchief or mask over the nose. Most farmers admitted that they only use protective clothing occasionally when it's available. The climate in Honduras is typical of tropical countries; it's hot and humid, which makes most protective clothing unappealing to the farmers. Long sleeve shirts and overalls are hot and increase a farmer's chance of heat stroke, or exposure by mingling sweat with pesticide fumes.

In 2000, the Central American region had one of the highest poisoning rates from agro-chemical exposure of 35 cases per 10,000 people. When adjusted for the population involved in agriculture this number jumps to 48 per 10,000 people (PAHO 2002, 6-7). While no farmers in this study reported using Extremely Hazardous pesticides (WHO IA), there were 4 different WHO IB (Highly Hazardous) pesticides used during this study and 12 WHO II (Moderately Hazardous). However, 11 chemicals were not registered by WHO, this could be because they were relatively new products, had very low toxicity or had not been associated with poisonings on a large enough scale to draw attention. It is unclear which of these chemicals are registered for use in Honduras and which, if any, are banned.

On average farmers spent US$ 154.46 every two weeks on fertilizers and US$ 50.48 weekly on pesticides. In addition, the most hazardous chemicals were among the most expensive and were used by farmers because of their perceived effectiveness. During the harvest season, farmers receive a median income of 7840.50 *lempiras* (US$ 435.58) per week from harvests. Of this 47% was used to buy chemicals. This calculation doesn't account for the cost of herbicide. In addition, this survey only looked at the use of fertilizers and pesticides during crop growth and production. Chemicals used to prepare the soil for planting or the use of herbicides for weeding were not considered in this study. Several farmers were observed using chemicals to kill weeds and Paraquat, which is on the Dirty Dozen list for the Central American region, was observed in several fields.

IPM Practices

The use of integrated pest management (IPM) techniques is one way NGO's and development organizations are trying to improve the health and environmental circumstances in rural areas. IPM does not necessarily mean eliminating the use of chemicals but if used appropriately it can reduce the amount of chemicals needed for crop production. IPM is more about strategizing the most effective combination of pest management techniques so that farmers can reduce their reliance on chemicals and yet maintain production levels. In this study 16 IPM techniques were examined to see which ones farmers used and statistical analysis was used to determine what were some of the decision making factors that led to certain practices being adopted.

The survey of IPM practices elicited a simple yes or no response, leaving it up to the farmers to decide whether or not they employed a given practice. In some cases, this resulted in fairly vague answers. For example, questions regarding the use of protective clothing were followed by more specific questions for clarification, i.e. "what types of clothing?" However, several subtleties in interpreting the questions did not become obvious until well into the study. For example, this study determined that virtually all farmers responded yes to "Do you weed?" It was not until late in the study that it became apparent that some farmers were responding outside of the IPM context, and considered the use of herbicides as a weeding practice. These observations were included in the results, but not the statistical analysis.

The use of barriers was included in this survey; however, its role as a pest deterrent is questionable when it is not used with trapping plants, as was the case in this study. The negative correlation between area access and the use of fixed traps or barriers might implies that farmers with larger amounts of land do not farm all of it at any given time, allowing the growth of “natural” traps and barriers between their crops. If the area access is limited to just that amount of land that is planted, then a positive correlation is observed with the use of barriers. However, since the ability of barriers as a pest management technique is weak, this could be a strategy for farmers to maximize their production by planting corn or millet around fields.

Geographical Analysis

In addition to the interview data and trends, this study demonstrates the value of GIS in development. Distance to markets or to training sites can be expected to influence a farmers decision to participate in extension activities, as well as influence planting decisions. Reasonable hypotheses are: 1) farmers closer to Comayagua would have a higher probability of being involved with FHIA, as FHIA is located in Comayaga, and 2) farmers further from Comayagua would be more likely to be members of a local cooperative to facilitate getting their produce to market. Surprisingly, distance to Comayagua was not a determining factor in whether or not farmers were affiliated with FHIA or members of a cooperative. Though not statistically proven, all farmers were located within the same radius and the average distance for FHIA affiliates was actually slightly higher than for non-affiliates. This finding is largely due to the complications in transportation in the months following the coup d'état and the reliance on FHIA for transportation into the field. As a result, the sample population was biased toward those within the FHIA working radius. Despite this, there was some evidence to suggest that farmers working with FHIA were located closer to a paved road (ease of access). Cooperative membership was independent of a farmer's involvement in the FHIA project. However there was still only a small difference in the average distances to Comayagua for members and non-members. This could again be the result of the limited radius from which the sample population derived. Neither participation in the FHIA Phase II project nor distance from the city was a determining factor in a farmer's likelihood of attending classes. , Over half of the farmers that weren't affiliated with FHIA had participated in classes on either pest management or IPM. If distance is a factor in these decisions, it lies outside of the radius of this study.

This type of analysis is very important in livelihood studies in which small farmers are responsible for transporting their goods to market. The methods presented here also offer a mechanism to calculate distances in remote areas where road or path data is not available. Variable on road type (dirt, gravel, paved, etc) and slope can also be used in ArcGIS to calculate total transportation costs. Unfortunately those variables were not collected, but they would have been very useful, especially since most roads in Honduras are not paved and the terrain is mountainous.

Future Studies

This study lays the groundwork for future studies on the costs and benefits of NTAE production, the use of agro-chemicals and the decision-making factors that can lead to the adoption of IPM techniques. There are several ways in which this study could be improved upon in order to better analyze these components for future investigations:

1) the most important study design change would be to increase the sample size. This study was limited in the number of independent farmers and area covered. This and similar studies, provide an important opportunity to evaluate the impact of extension work on small farmers. Future studies should include more farmers and cover more area to allow for comparison of distant farming communities with those nearer to Comayagua.

2) Variables on road type (dirt, gravel, paved, etc) and slope can be used in ArcGIS to calculate total transportation costs. Inclusion of these variables in the data collected would be very useful in countries like Honduras, where most roads are not paved and the terrain is mountainous.

3) A year long study period would provide more accurate market information by including market cycles and fluctuating prices for vegetables. A more complete picture of fertilizer and pesticide use between the different phases of crop growth (pre-germination, pre-harvest, and during harvest) could be captured over the longer time period.

4) All agro-chemicals, including herbicides, should be included. This should include price surveys at local cooperatives to verify and produce a more complete cost analysis.

5) Capturing an accurate picture of the role of IPM in rural farming can be enhanced through cultural acclimation prior to beginning field work. By

allocating sufficient time to learn local customs, all locally used IPM techniques can be included in the survey, and the questions designed with the specificity required to capture the data accurately. A good example of this was the use of protective clothing. Farmers often claimed they didn’t use protective clothing, even if they were wearing rubber boots during the interview.

CHAPTER FIVE: SUMMARY

This study focuses on the development role of pesticides and chemical fertilizers on non-traditional agricultural export farming and the use IPM techniques. The data were collected through surveys, field observations, and the collection of GPS points. Survey responses and observations were used to identify trends and patterns while statistical analysis was used to examine the likelihood of the use of certain IPM techniques based on farmer characteristics, and GIS analysis was used to examine the role that distance from market played in a farmer's participation in development projects and decision-making. Unfortunately, the study sample population was small and therefore difficult to determine anything significant.

The high frequency with which farmers apply agro-chemicals is disturbing on several levels. Even now, the long term effects of agro-chemicals, especially the biocides, on human health or the environment are not fully understood and several chemicals that were used in this study are still unregistered by WHO. In addition the slow reaction time of some of these chemicals means that we will feel the effects of our actions for many years. However, this study as also revealed some positive observations. The most toxic pesticides were rarely used, most chemicals belonged to the Moderately Hazardous (WHO II) or to the category "unlikely to present hazard" (WHO V) and farmers have a relatively steady income in NTAE production.

The use of certain IPM techniques is common among farmers. The amount of land a farmer had access and how much he actually planted seemed to be determining factors in his decision to use fixed traps and barriers. With a larger sample size it could be determined how land access affects a farmer's decision in these and other IPM techniques. Overall, Asian vegetable production is a viable economic activity for small farmers in rural Honduras. However, more studies are needed to fully understand costs and benefits of producing vegetable solely for export and the decision-making process for how small farmers.

REFERENCES

Aragón, A., C. Aragón and A. Thörn. "Pests, Peasants, and Pesticides on the Northern Nicaraguan Pacific Plain." *International Journal of Occupational and Environmental Health* 7 (2001): 295-302.

Atreya, K. "Pesticide use knowledge and practices: A gender differences in Nepal." *Environmental Research*. 104 (2007): 305 – 311.

Boucher, Stephen R, Bradford L. Barham and Michael R. Carter. "The Impact of 'Market-Friendly' Reforms in Honduras and Nicaragua." *World Development.* 33 no. 1 (2005): 107-128.

Brockett, Charles D. "Public Policy, Peasants, and Rural Development in Honduras." Journal of Latin America Studies. 19(1987): 69-86.

Brockett, Charles D. *Land, Power, and Poverty: Agrarian Transformation and Political Conflict in Central America.* Boulder: Westview Press, 1998.

Brodesser, J., Byron, D.H., Cannavan, A., Ferris, I.G., Gross-Helmert, K., Hendrichs, J., Maestroni, B.M., Unsworth, J., Vaagt, G., and Zapata, F. "Pesticides in developing countries and the International Code of Conduct on the Distribution and the Use of Pesticides". Austrian Agency for Health and Food Safety (AGES) Meeting on Risks and Benefits of Pesticides, Vienna, Austria, 30 March 2006.

Central Intelligence Agency. "World Factbook: Honduras," 2010 https://www.cia.gov/library/publications/the-world-factbook/geos/ho.html#

DeWalt, Billie R., P. Vergne and M. Hardin. "Shrimp Aquaculture Development and the Environment: People, Mangroves and Fisheries on the Gulf of Fonseca, Honduras." *World Development* 24 (1996): 1193-1208.

Dich, J., S.H. Zahm, A. Hanberg and H.O. Adami. "Pesticides and Cancers." *Cancer Causes and Control* 8 (1997): 420-443.

Durham, William H. *Scarcity and Survival in Central America: Ecological origins of the Soccer War.* Stanford: Stanford University Press, 1979.

Galt, Ryan E. "Beyond the Circle of Poison: Significant shifts in the global pesticide complex, 1976-2008." *Global Environmental Change* 18 (2008): 786-799.

Galt, Ryan E. "Overlap of US FDA residue tests and pesticides used on imported vegetables: Empirical findings and policy recommendations." *Food Policy* 34 (2009): 468-476.

García, Ana M. "Pesticide exposure and women's health." *American Journal of Industrial Medicine.* 44 (2003): 584-594.

Hamilton, S. and E.F. Fischer. "Non-Traditional Agriculture Exports in Highland Guatemala: Understandings of risk and perceptions of change." *Latin American Research Review* 38 (2003): 82-110.

Hetch, S.B., S. Kandel, I. Gomes, N. Cuellar and H. Rosa. "Globalization, Forest Resurgence, and Environmental Politics in El Salvador." *World Development* 34 (2006): 308-323.

Hobdin, Stephen. 2008. The developing world in the global economy. In *Politics in the Developing World,* ed. P. Burnell and V. Randall, 53-87. 2d ed. New York: Oxford University Press.

Hodgson, Ernest and Patricia E. Levi. "Pesticides: An important but underused model for the environmental health sciences." *Environmental Health Perspectives*. 104 (1996): 97-106.

Hruska, A.J. and M. Corriols. "The Impact of Training in Integrated Pest Management among Nicaraguan Maize Farmers: Increased net returns and reduced risk." *International Journal of Occupational and Environmental Health* 8 (2002): 191-200.

Imbruce, V. "The Production Relations of Contract Farming in Honduras." *GeoJournal* 73 (2008): 67-82.

International Food Policy Research Institute (IFPRI). *Green Revolution: Curse or blessing?* Washington DC: International Food and Policy Institute. 2002.

Jansen, Hans G.P, P.B. Siegel, J. Alwang, and F. Pichón. "Geography, Livelihoods and Rural Poverty in Honduras: An Empirical Analysis using an Asset-base Approach." *Ibero-America Institute for Economic Research (IAI) Discussion Papers* 134 (2005): 1-41.

Jansen, Kees. "The Unspeakable Ban: The Translation of Global Pesticide Governance into Honduran National." *World Development* 36 (2008):575-589.

Kay, Cristóbal. "Reflections on rural violence in Latin America." *Third World Quarterly* 22, no 5 (2001): 741-775.

Kerbo, Harold R. 2006. Global and world poverty: Limitations and tools for sustainable development. In *World Poverty: Global inequality and the modern world system,* ed. H.R. Kerbo, 240-264. Boston: McGrall Hill.

Krznaric, Roman. "The Limits on Pro-poor Agriculture Trade in Guatemala: Land, Labour and Political Power." *Journal of Human Development* 7 (2006): 111-135.

Law and Democracy in Latin America. 2005. http://www.laits.utexas.edu/lawdem/unit03/reading2/Gini_inequality_region.html.

Longo, Stefano and Richard York. “Agricultural exports and the environment: A cross-national study of fertilizers and pesticide consumption.” *Rural Sociology* (March): 82-104, 2008.

London, Leslie, Sylvie Grosbois, Catharina Wesseling, Sophia Kisting, Hanna A. Rother, and Donna Mergler. “Pesticide Usage and Health Consequences for Women in Developing Countries: Out of Sight, Out of Mind?” *International Journal of Occupational and Environmental Health.* 8 (2002): 46-59.

Madrazo, Laura O’Docherty. “The Hidden Face of the War in Central America.” *Current Sociolog.*36 (1988): 93-106.

Mahon, James E. Jr. “Good-Bye to the Washington Consensus?” *Current History* (February) 2003: 58-64.

Mey, Brenda J.V. “Establishing Gender Sensitive IPM: A cowpea programme in Ghanna.” In *Women and IPM: Crop protection practices and strategies*. Ed by Elske van de Fliert and Jet Proost, 39-50. Amsterdam: Royal Tropical Institute, 1999.

Miranda, J., I. Lundberg, R. McConnell, E. Delgado, R. Cuada, E. Torres, C. Wesseling, M. and Keifer. “Onset of Grip- and Pinch-Strength Impairment after Acute Poisonings with Organophosphate Insecticides.” *International Journal of Occupational and Environmental Health* 8 (2002): 19-26.

Morales, Helda and Ivette Perfecto. “Traditional Knowledge and Pest Management in the Guatemalan Highlands.” *Agriculture and Human Values* 17 (2000): 49-63.

Murray, Douglas L. *Cultivating Crisis: The human cost of pesticides in Latin America.* Austin: University of Texas Press, 1994

Murray, D., C. Wesseling, M. Keifer, M. Corriols and S. Henao. “Surveillance of Pesticide-related Illness in the Developing World: Putting the Data to Work.” *International Journal of Occupational and Environmental Health* 8 (2002): 243-248.

Murray, D. and P. Hoppin. “Recurring Contradictions in Agrarian Development: Pesticide problems in Caribbean Basin nontraditional agriculture.” *World Development* 20 (1992): 597-608.

NPIC and EXTOXNET websites. “National Pesticide Information Center.” http://pi.ace.orst.edu/search/libs.jsp

Natural Resources Institute (NRI). *Gender Issues in Integrated Pest Management in African Agriculture.* Natural Resources Institute Socio-economic Series 5. 1994 http://nzdl.sadl.uteth.ca/cgi-bin/library?e=d-00000-00---off-0envl--00-0--0-10-0---0---0prompt-00&a=d&cl=CL3.19&d=HASH0178d359

Office of the United States Trade Representative. *CAFTA-DR Final Text.* (2004), http://www.ustr.gov/Trade_Agreements/Bilateral/CAFTA/CAFTA-DR_Final_Texts/Section_Index.html

Pan American Health Organization. "Epidemiological Situation of Acute Pesticide Poisoning in Central American Isthmus, 1992-200." *Epidemiological Bulletin* 23 (2002), http://www.paho.org/English/SHA/be_v23n3-plaguicidas.htm

Rengam, Sarojeni V. "The struggle against pesticides". In *Women and IPM: crop protection practices and strategies.* Edited by Elske van de Fliert and Jet Proost, 15-21. Amsterdam: Royal Tropical Institute, 1999.

Reynolds, L.T., D. Murray and A. Heller. "Regulating Sustainability in the Coffee Sector: A comparative analysis of third-party environmental and social certification initiatives." *Agriculture and Human Values* 24 (2007): 147-163.

Rosenthal, Erika. "Who's Afraid of National Laws?: Pesticide corporations use trade negotiations to avoid bans and undercut public health protections in Central America." *International Journal of Occupational and Environmental Health* 11 (2005): 437-443.

Ruhl, J. Mark. "Agrarian Structure and Political Stability in Honduras." *Journal of Inter American Studies and World Affairs* 26, no 1 (1984): 33-68.

Sieder, Rachel. "Honduras: The Politics of Exception and Military Reformism (1972-1978)." *Journal of Latin American Studies,* 27 (1995): 99-127.

Smith, Carl. "Pesticide Exports from U.S. Ports, 1997-2000." *International Journal of Occupational and Environmental Health* 7 (2001): 266-274.

Stonich, Susan C. *"I Am Destroying The Land!": The Political Ecology of Poverty and Environmental Destruction in Honduras.* Boulder: Westview Press, 1993.

Tabellini, Guido. 2005. The role of the state in economic development. In *KYKLOS* 58:2 (2005) 283-303.

Thrupp, Lori Ann. *Bittersweet Harvest for Global Supermarkets: Challenges in Latin America's agriculture export boom.* World Resources Institute, 1995.

Thrupp, Lori Ann. "Inappropriate Incentives for Pesticide Use: Agricultural credit requirements in developing countries." *Agriculture and Human Values* (1990): 62-69.

Tovar, L.G, L. Martin, M.A.G. Cruz and T. Mutersbaugh. "Certified Organic Agriculture in Mexico: Market connections and certification practices in large and small producers." *Journal of Rural Studies* 21 (2005): 461-474.

Watson, Kelly and Moira L. Achinelli. "Context and Contingency: The coffee crisis for conventional small-scale coffee farmers in Brazil." *The Geographical Journal* (September 2008): 223-234.

Welsch, Friedrich J and José V. Carrasquero. *Perceptions of State Reform in Latin America.* Oxford: United Nations Educational, Scientific and Cultural Organization, 2000.

Wesseling, C., M. Corriols and V. Bravo. "Acute Pesticide Poisoning and Pesticide Registration in Central America." *Toxicology and Applied Pharmacology* 207 (2005):697-705.

Williams, Robert G. *Export Agriculture and the Crisis in Central America.* Chapel Hill: The University of North Carolina Press, 1986.

World Bank: Honduras Data
http://data.worldbank.org/country/honduras

World Health Organization (WHO). *The WHO Recommended Classification of Pesticides by Hazard.* Geneva: World Health Organization. 2004.